HYBRID MOBILITY DEVICE

CALIFORNIA STATE UNIVERSITY OF LOS ANGELES

COLLEGE OF ENGINEERING, COMPUTER SCIENCE AND TECHNOLOGY

ADVISOR: ADEL SHARIF

Agenda

- Introduction
- Project Management
- Mechanical Process
- Power System Process
- Design Assessment
- Conclusion

Introduction

- Team Introduction
- Background
- Objective
- Requirements
- Society Impact Factors

MECHANICAL SYSTEM TEAM

Cristopher Santiago

Mechanical Engineer
Chain Guide
Mechanism design
Team Leader

Abdullah Alshammari

Mechanical Engineer
Roll Cage
Seat Design

Noemi Lucas

Mechanical Engineer
FEA
Drawings
Seatbelt
Safety

Christopher Perez

Mechanical Engineer
Design Gear
Mechanism

Hussam Alzahrani

Mechanical Engineer
Roll Cage
Seat Design

POWER SYSTEM TEAM

Adrian Gonzalez	Brian Castillo	Diego Monterroso	Gavino Saenz	Juan Estrada	Helen Cedillos
					
Mechanical Engineer Battery Management	**Electrical Engineer** Control Systems	**Mechanical Engineer** Solar Cell	**Mechanical Engineer** Solar Cell	**Mechanical Engineer** Motor	**Mechanical Engineer** Control Systems Team Leader

Problem - Transportation

- Global Warming
- Pollution
- Traffic
- Expensive
- Maintenance

SOLUTION

Eco-friendly

Health

Reduce Greenhouse Gas Emission

Cheaper alternative compared to vehicles.

SOCIETY IMPACT & FACTORS

- Encourage more efficient vehicles and a better way of commuting with minimal environmental impact
- Eliminate road congestion
- Lower Carbon Emissions

OBJECTIVE

Lightweight Hybrid Mobility Vehicle

- Alternate form of transportation
- Eco Friendly
- Slim tadpole design

Power System Team

- Design and integrate:
  - Electric Powertrain
  - Renewable Energy Source

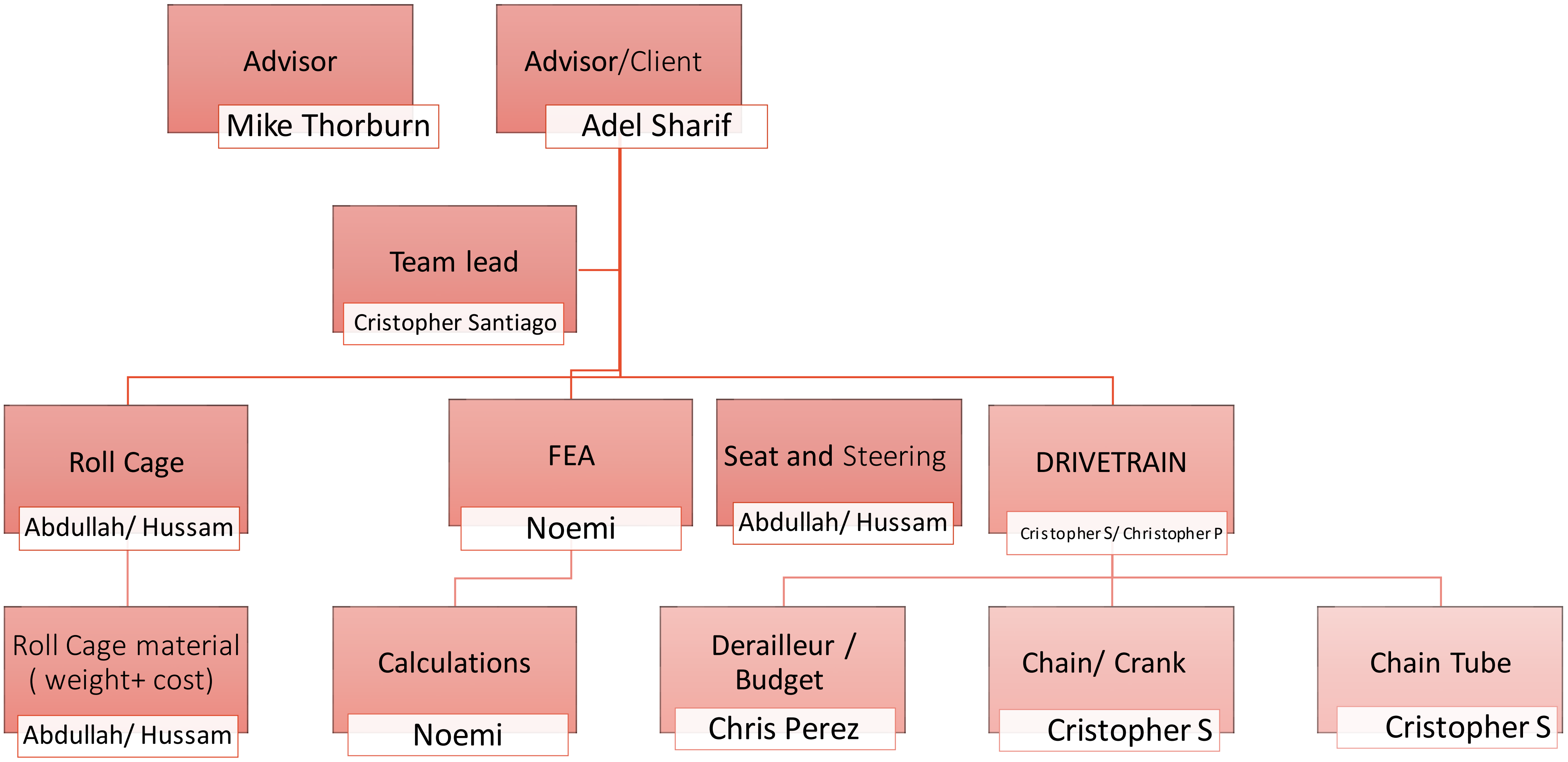
Mechanical Systems Team

- Design a roll cage
- Finite Element Analysis (FEA)
- Finalize the drivetrain

Project Management

Team	Team Structure
Work	Work Breakdown Structure
Schedule	Deliverables

Mechanical Team



DELIVERABLES

MECHANICAL

This part of the project were divided into 4 phases:

Phase I: Determining the essintial parts of the project as well as doing research to better understand the project.

Phase II: Providing concept designs and move forward with final design .

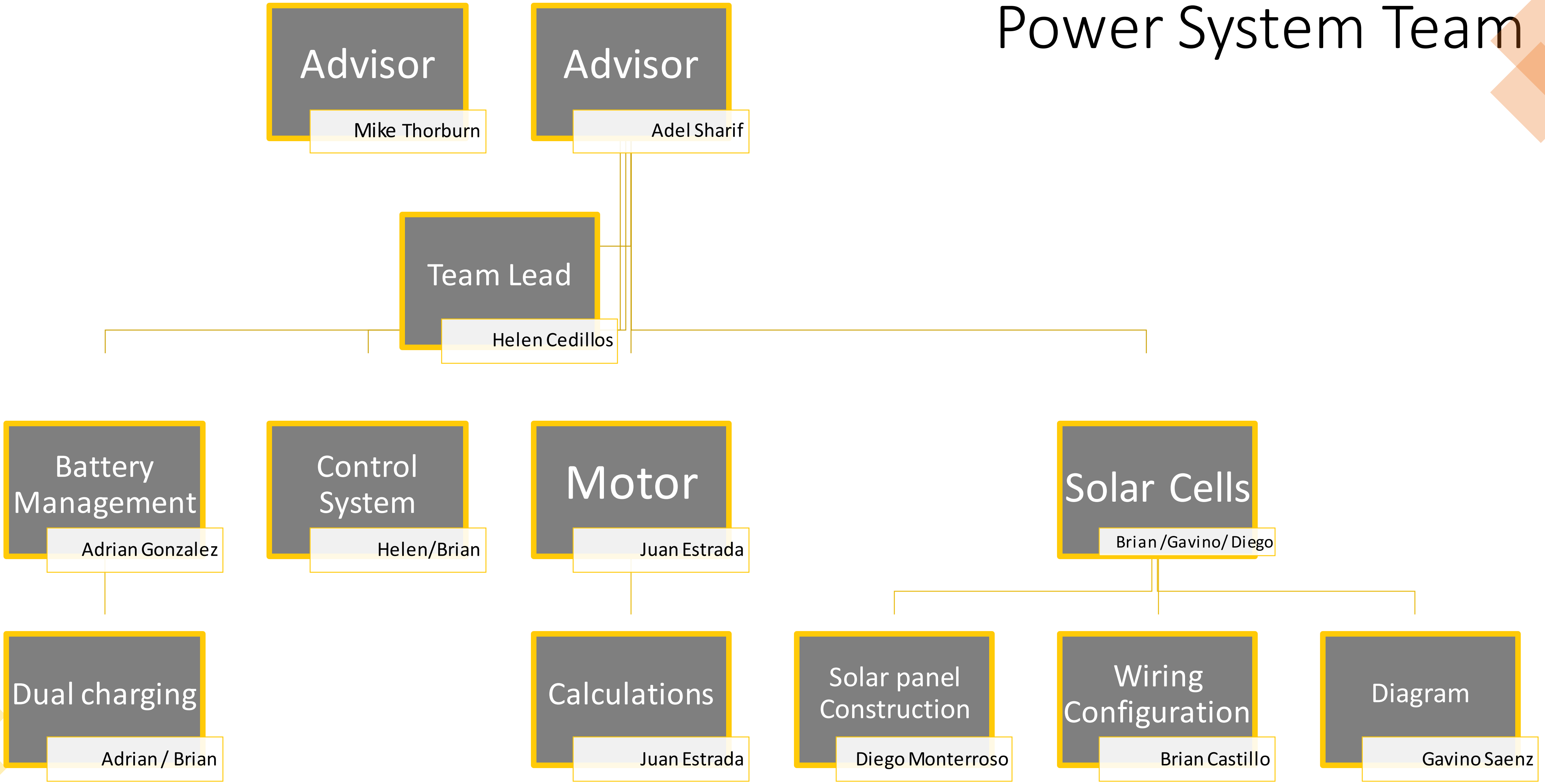
Phase III: Testing and simulate

Phase IV: Finalize work, present final product.

WORK BREAKDOWN STRUCTURE

WBS	Task	Lead
	Phase 1 - Research	
1.1	Roll Cage	Hussam / Abdullah
1.2	Drivetrain	Cristopher S/ Christopher Perez
1.3	FEA (Finite Element Analysis)	Noemi
1.4	Seat	Cristopher S /Hussam / Abdullah
	Phase 2 - Design	
2.1	Roll Cage	Hussam / Abdullah
2.2	Drivetrain	Cristopher S/ Christopher Perez
2.3	FEA (Finite Element Analysis)	Noemi
2.4	Seat Design	Hussam / Abdullah / Cristopher S
	Phase 3 - Build and Test or Simulations	
3.1	Design Roll Cage/ Drivetrain	Mechanical Systems
3.2	Meet all Design Requirements	Mechanical Systems
3.3	Design Seat	Mechanical Systems
3.4	Present Modifications to Advisor	Mechanical Systems
	Phase 4 – Finalize and Present	
4.1	Demonstrate Final Project	Mechanical Systems
4.2	Present	Mechanical Systems

Power System Team



DELIVERABLES

Phase I

Identify the main parts

Research to develop understanding

Phase II

Start designing

Integrate the subsystem together

Phase III

Building shall start

Testing

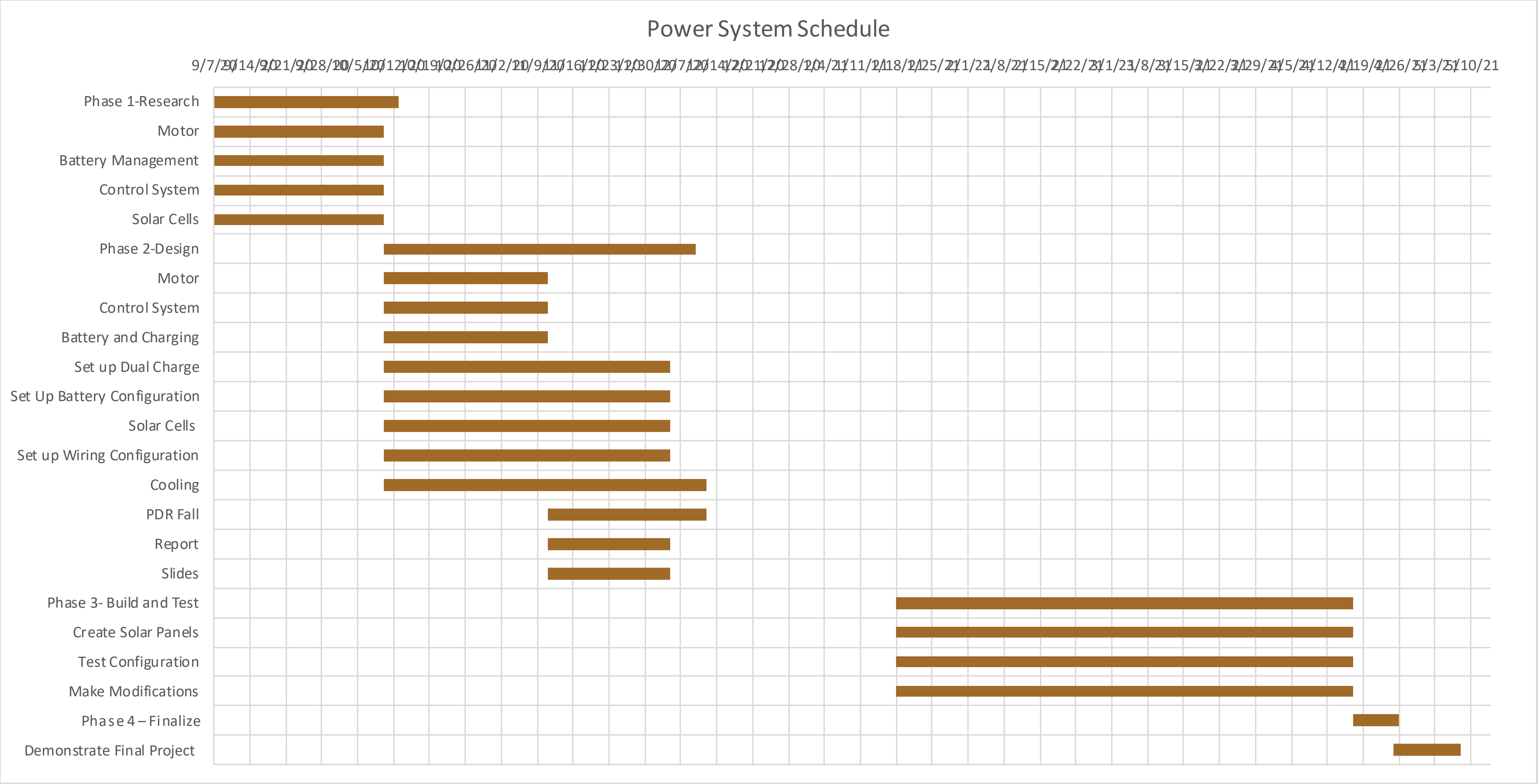
Stimulations will be created in the event the school does not open

Phase IV

Present Finish Product

WORK BREAKDOWN STRUCTURE

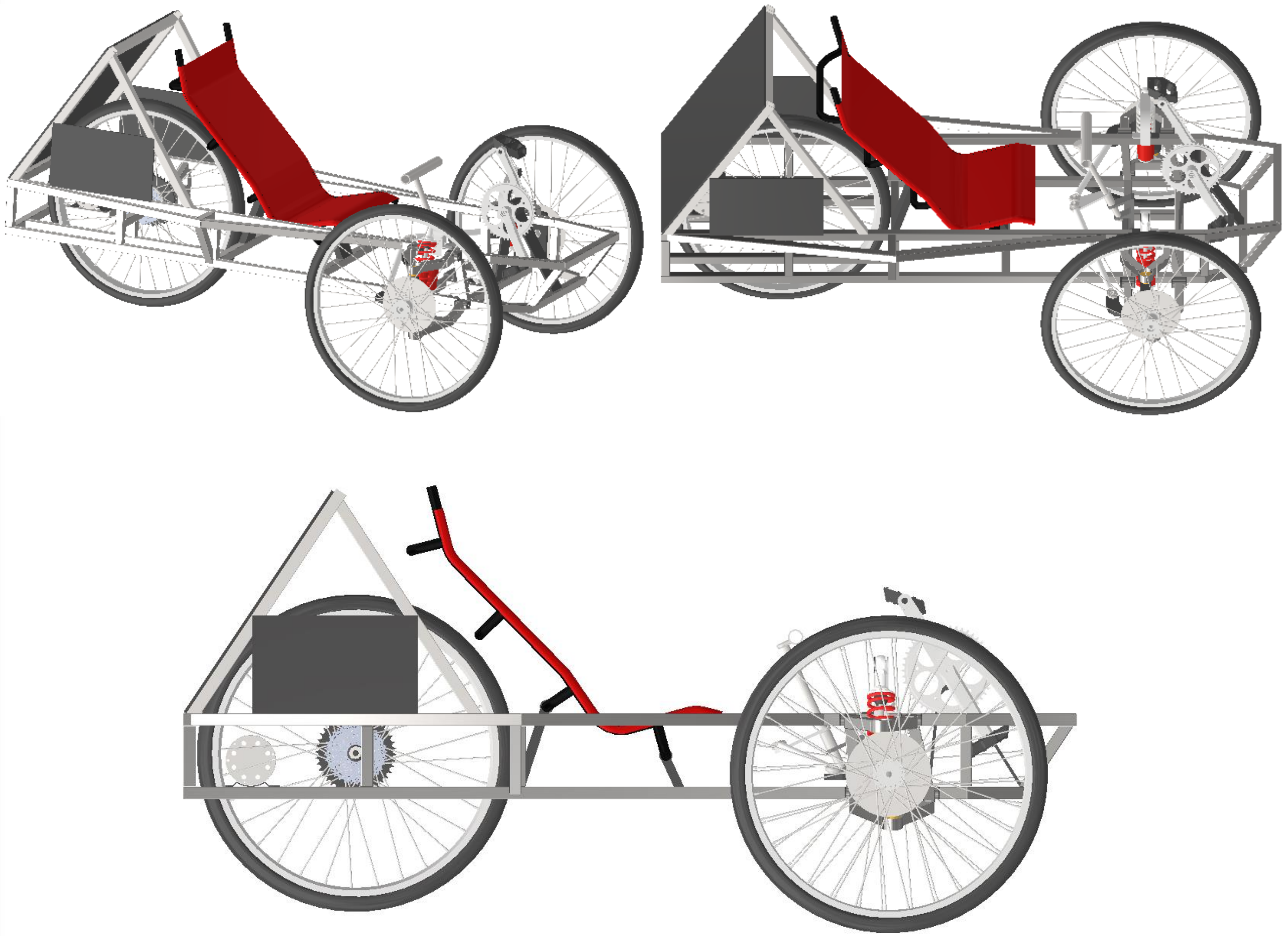
WBS	Task	Lead
	Phase 1 - Research	
1.1	Motor	Juan
1.2	Battery Management	Adrian
1.3	Control System	Brian/ Helen
1.4	Solar Cells	Gavino / Diego/Brian
	Phase 2 – Design	
2.1	Motor	Juan
2.2	Control System	Brian / Helen
2.3	Battery and Charging	Adrian/ Brian / Helen
2.3.1	Set Up Dual Charging	Gavino/ Diego/ Brian
2.3.2	Set Up Battery Configuration	Brian/ Gavino
2.4	Solar Cell	Diego/ Gavino
2.4.1	Set Up Wiring Configuration	Gavino/Diego
	Phase 3- Build [Simulations] and Run Test	
3.1	Create Solar Panels	Power System Team
3.2	Test Configuration	Power System Team
3.3	Make Modification	Power System Team
	Phase 4 – Finalize and Present	
4.1	Demonstrate Final Project	Power System Team
4.2	Present	Power System Team


Power System Schedule
Phase 1-Research
Motor
Battery Management
Control System
Solar Cells
Phase 2-Design
Motor
Control System
Battery and Charging
Set up Dual Charge
Set Up Battery Configuration
Solar Cells
Set up Wiring Configuration
Cooling
PDR Fall
Report
Slides
Phase 3- Build and Test
Create Solar Panels
Test Configuration
Make Modifications
Phase 4 – Finalize
Demonstrate Final Project

MECHANICAL SYSTEMS

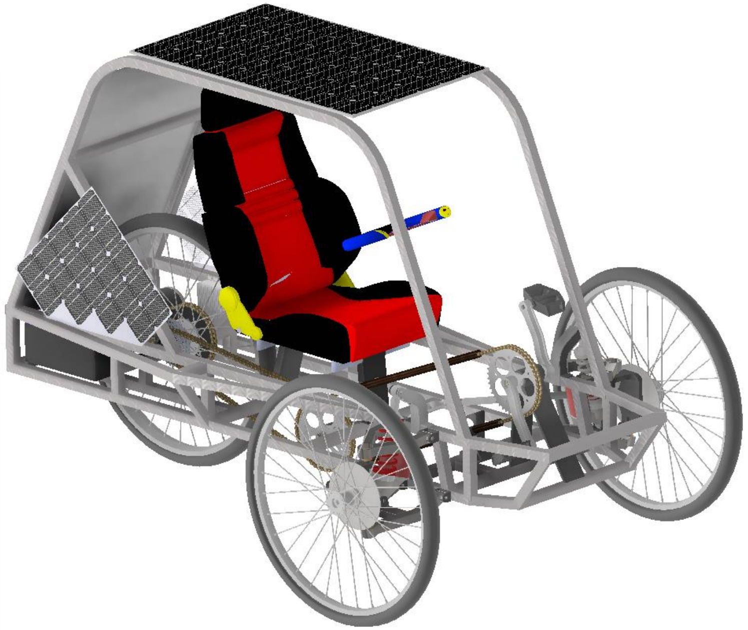
ROLL CAGE DESIGN

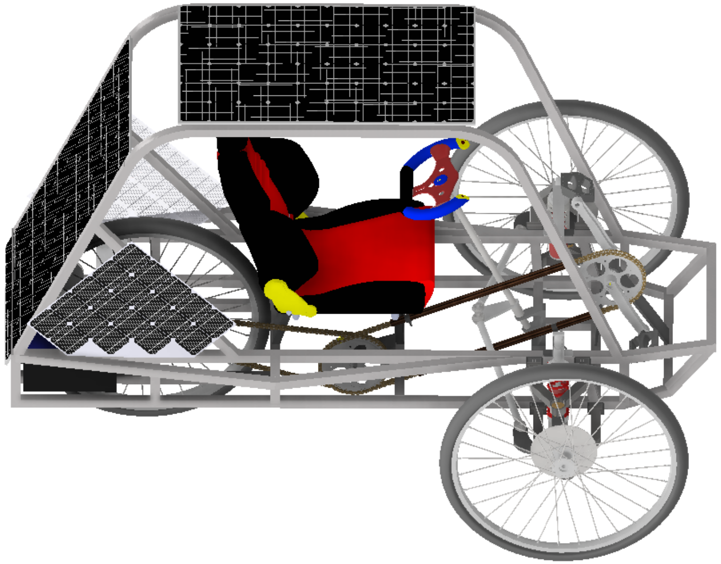
- High risk and low safety.
- Research on roll cage designs.
- Not enough space to place solar cells to meet the electrical team needs.
- Started the design process to increase the safety and to take advantage of the space on top of the roll cage.

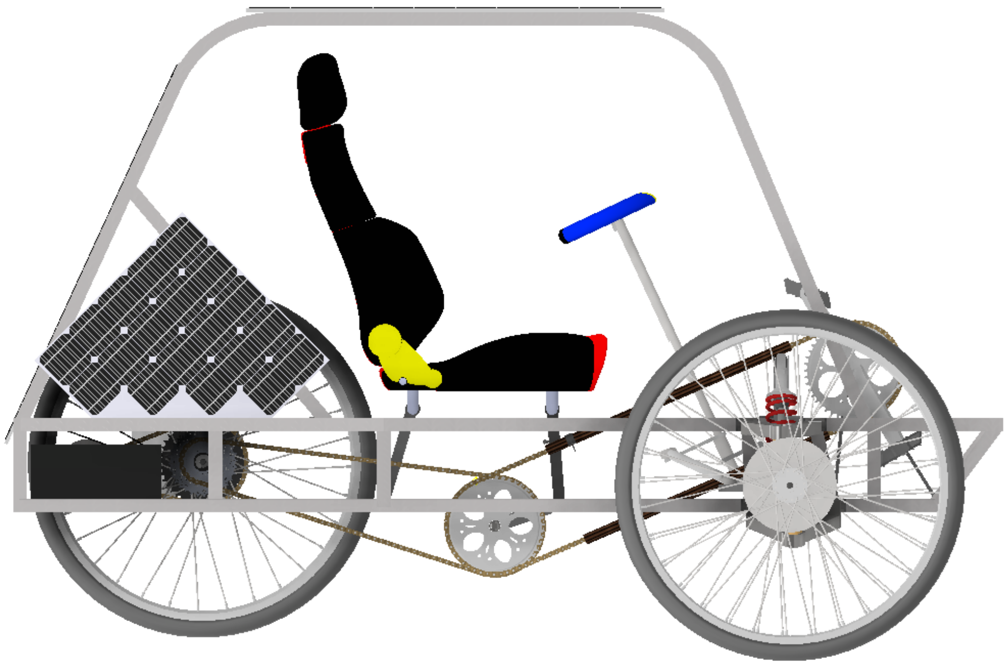


ROLL CAGE
New design

- 1. Designed a roll cage to protect the driver from being injured.
- 2. Mild steel were used to design the roll cage with 1-inch square tubing and 0.065 inch of wall thickness.
- 3. Increased the top space of the roll cage to place the soral cells.
- 4. Curved the corner of the roll cage to minimize the stress





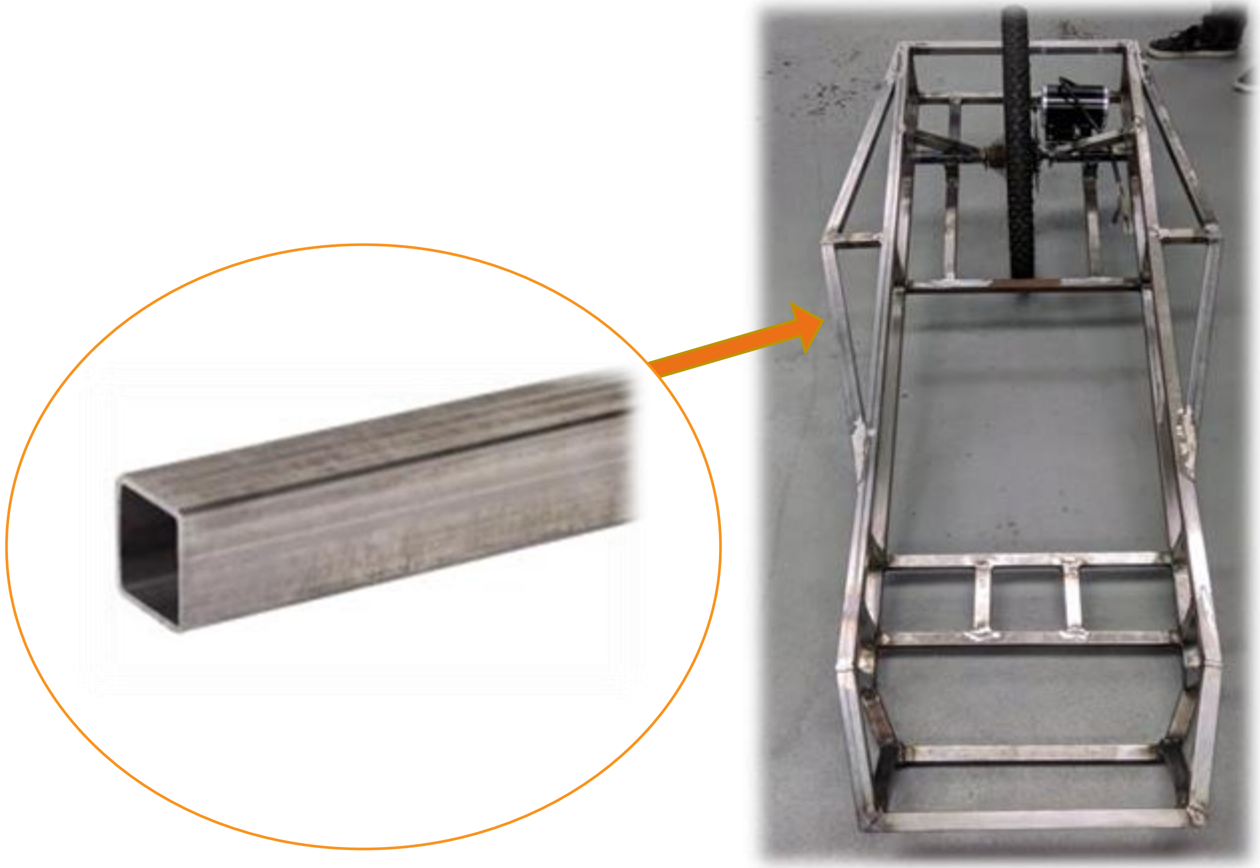


ROLL CAGE - ANALYSIS

- If Analysis is done correctly, it reduces the time and cost when building.
- The material selected: Steel mild
- Multiple analysis was done on roll cage.
  - Front impact
  - Roll over
  - Side impact

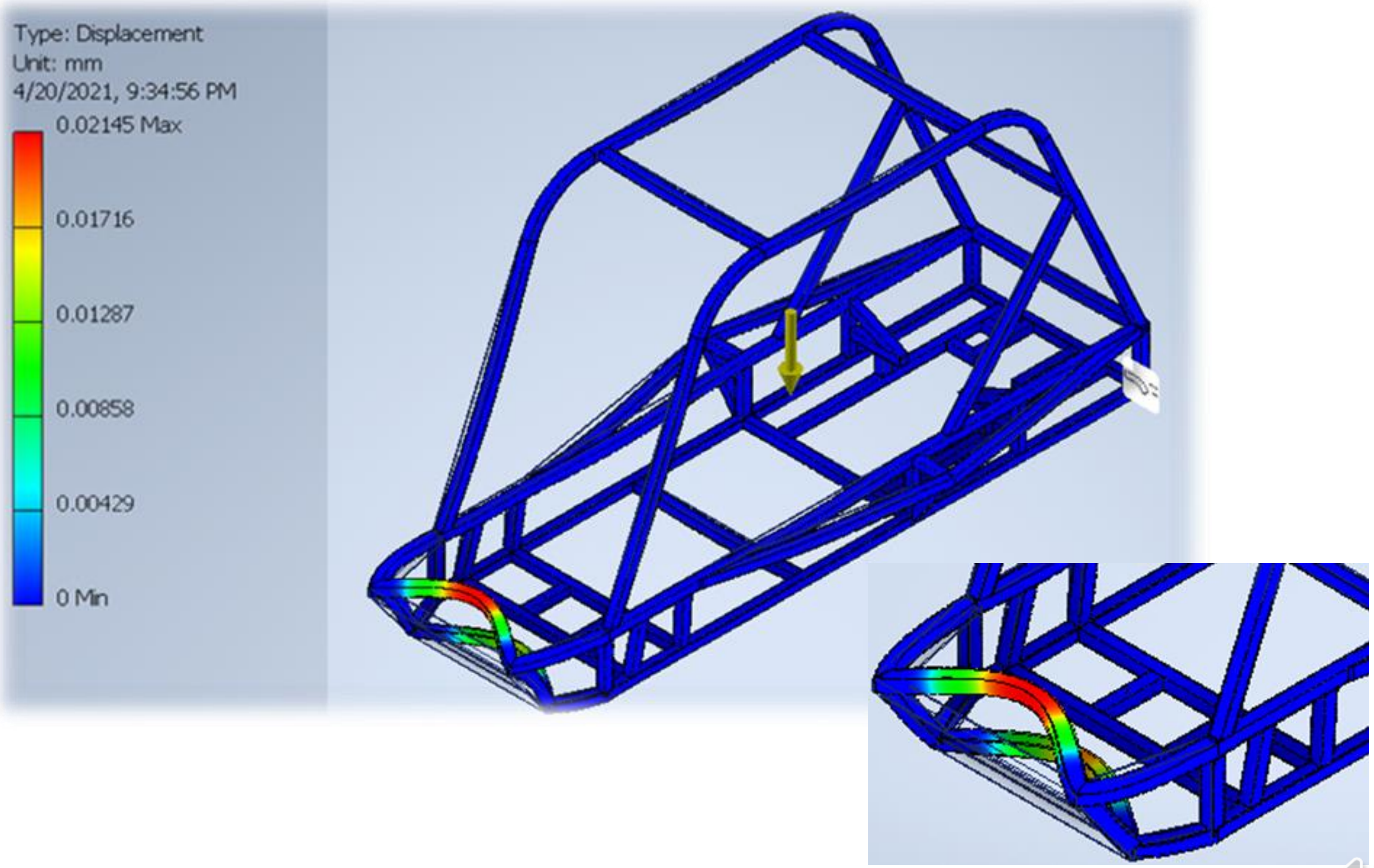
Mild Steel

- 1-inch square tubing
- Primarily made up of steel or iron.
- Commonly used in fabrication
- Versatile
- Simple metal available when it comes to welding
- Least amount of PPE

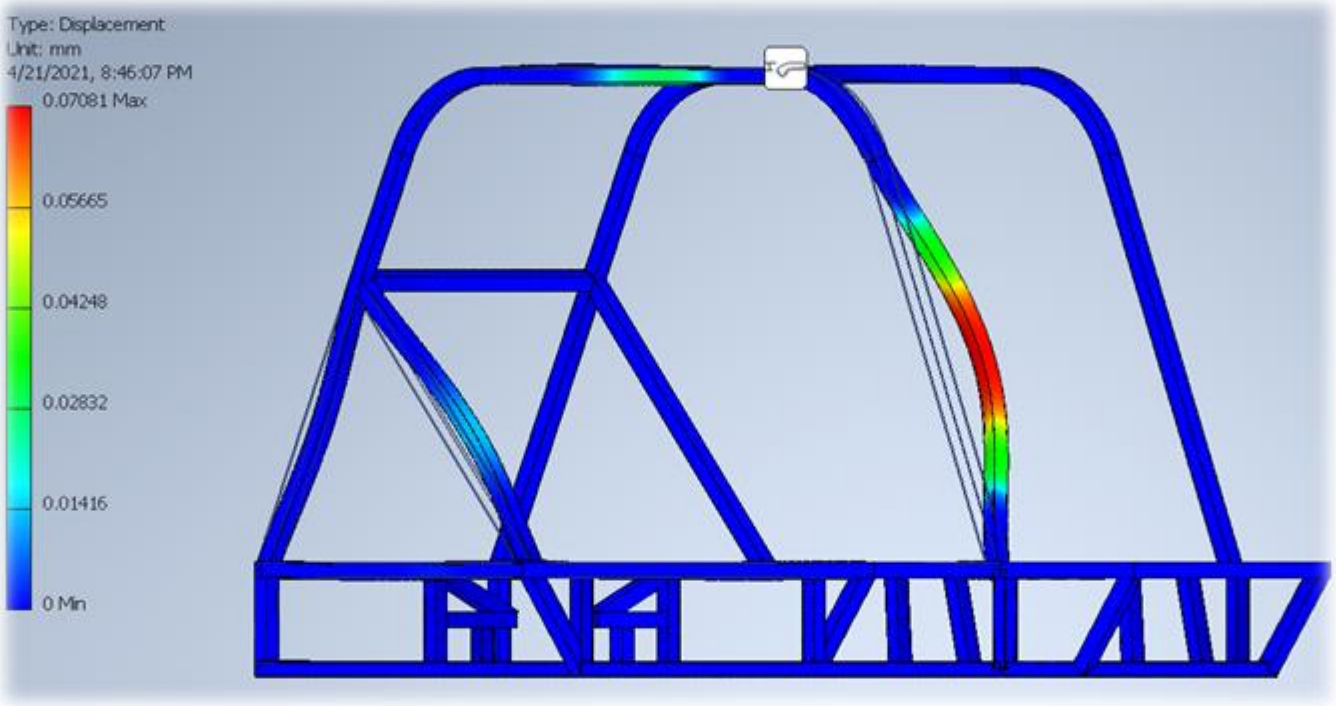


FRONT IMPACT - ANALYSIS

- Total Mass: 400 lb.
- Initial velocity: 25 mph
- Work done: 11331 J
- Impact time: 0.25 s
- Acceleration: 44.7 m/s^2
- Displacement: 1.397 m
- Impact force: 8110 N



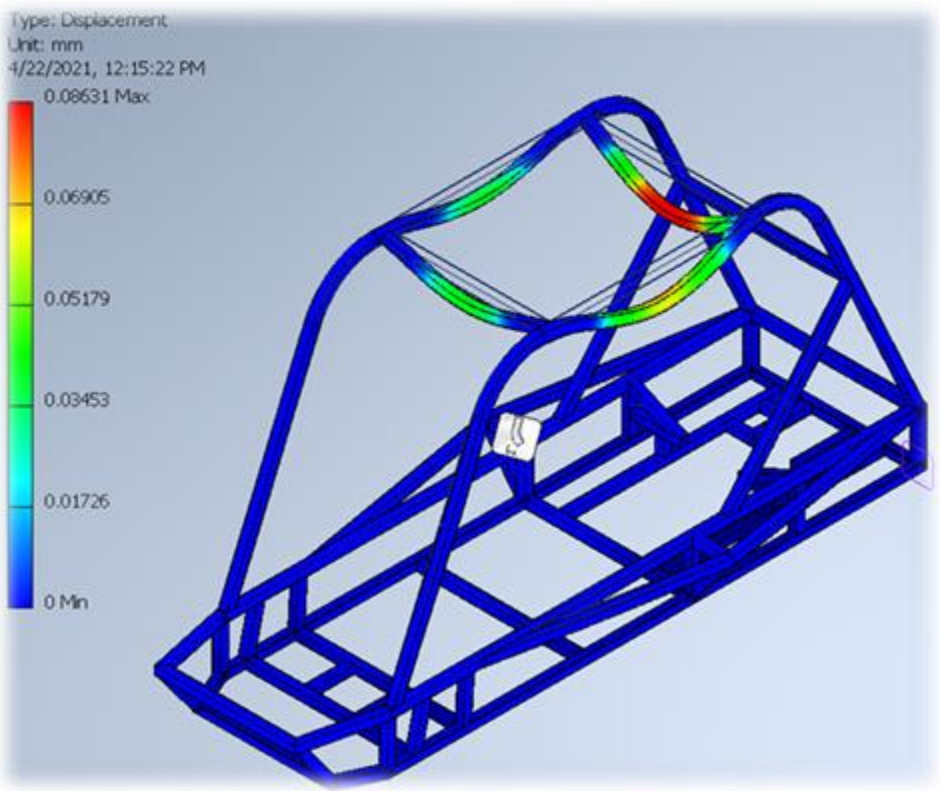
SIDE IMPACT - ANALYSIS

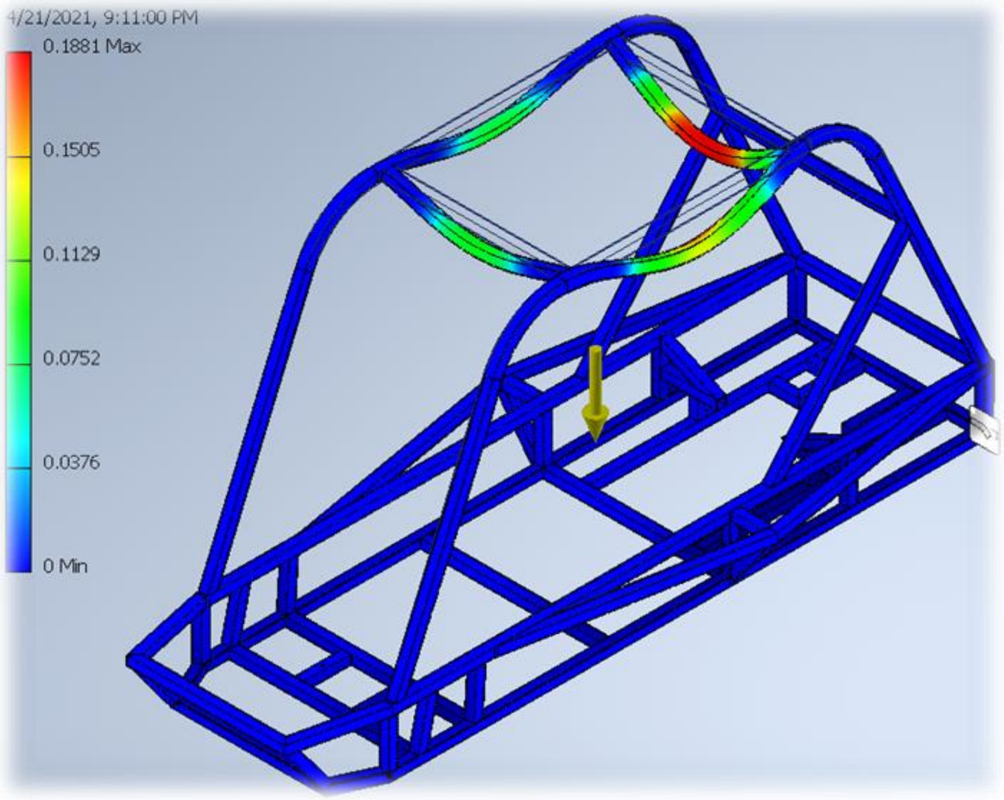


- Impact force 8110 N
- Located in 8 different nodes.
- Impact force each node

  1013.75N

ROLL IMPACT - ANALYSIS



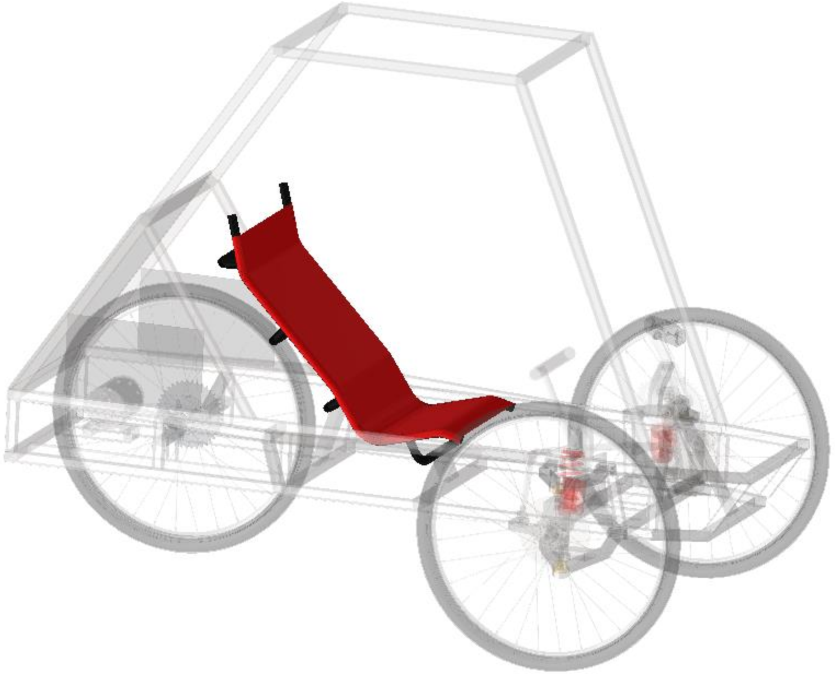


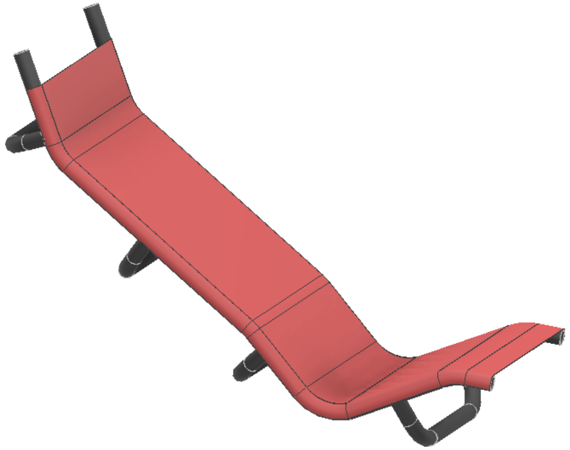
Seats Design

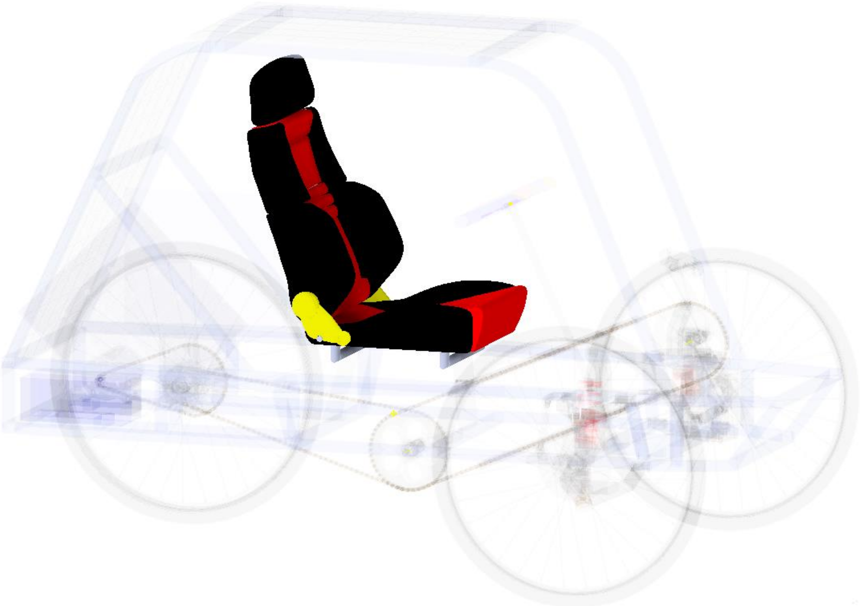
1. Designed a new seat that fits the dimension of the vehicle.

2. More comfortable and stable

3. Better grip and more secure while driving

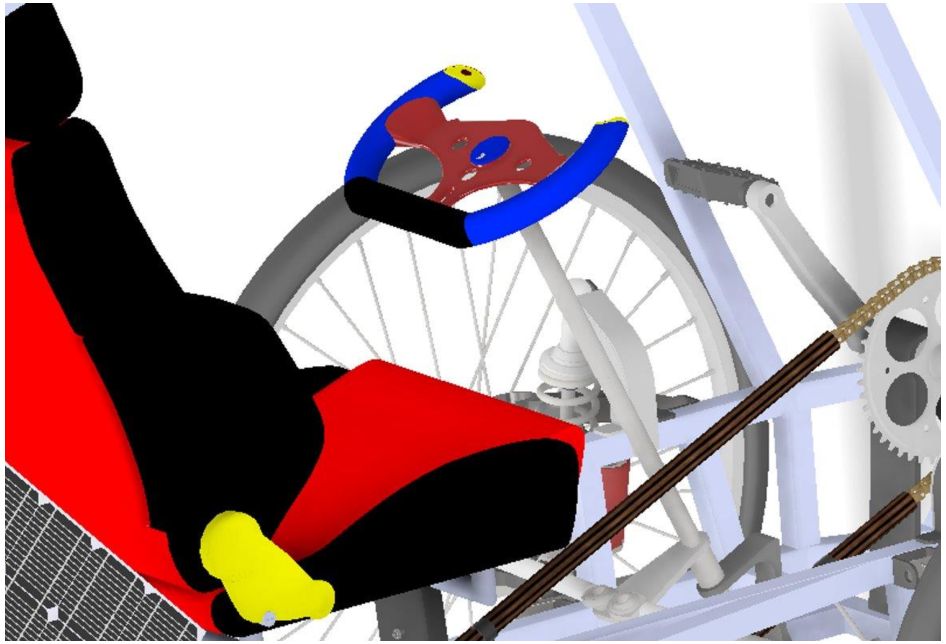






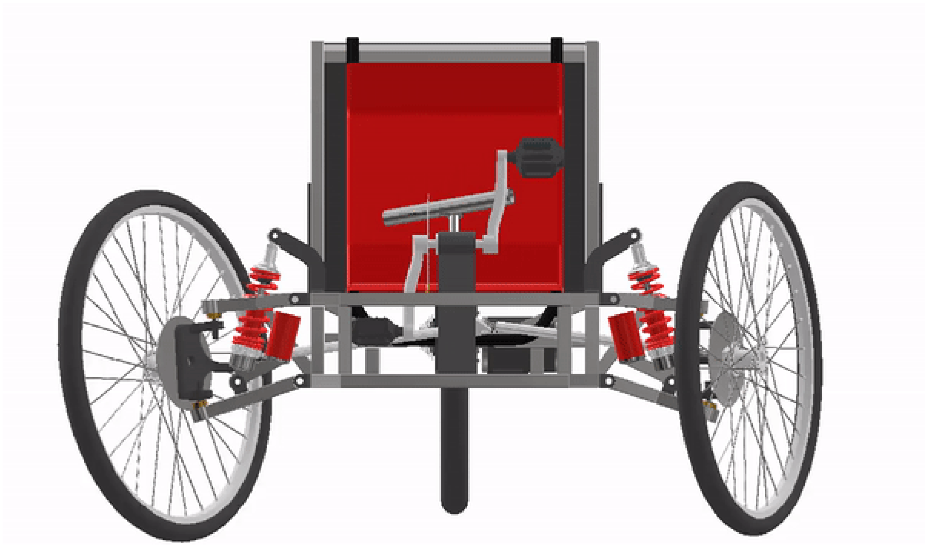
Steering Wheels

- Design issues
- Modifications
- Interfere with pedaling
- This design better for steering



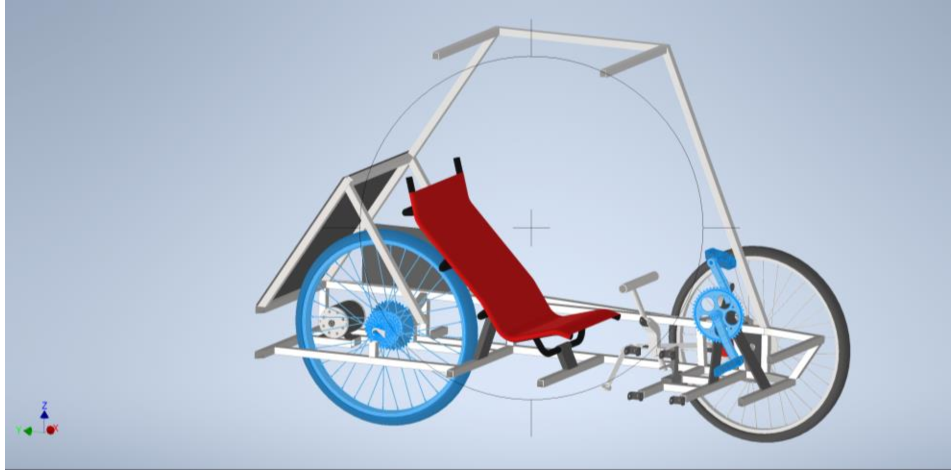
SUSPENSION

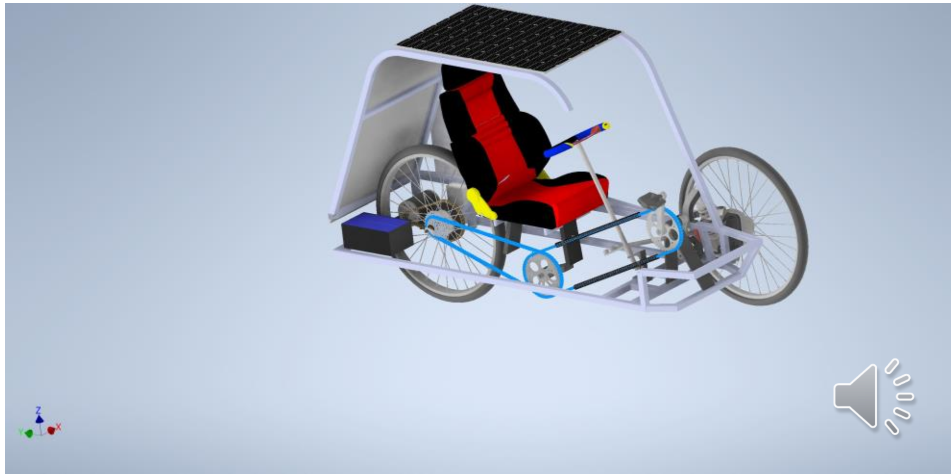
- Double wishbone suspension
- Kingpin inclination (KPI)
- Caster
- Ackermann steering



DRIVETRAIN

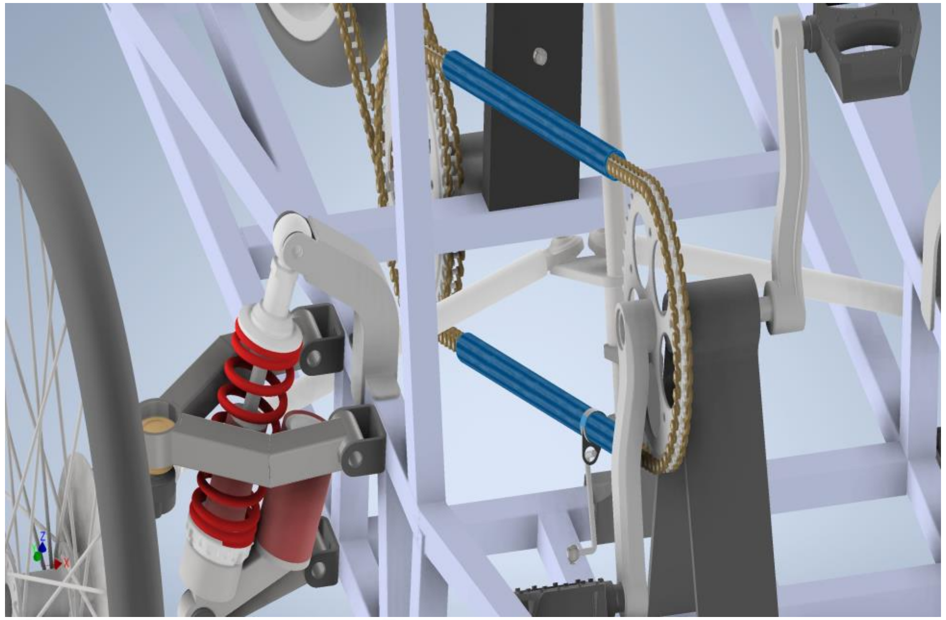
- Additional Crank Design
- Rear 9 speed sprocket
- Gears will allow the driver to pedal with ease in elevated area when driving manually
- Pros of the new design
- Cons of previous design how it interfered with the seat





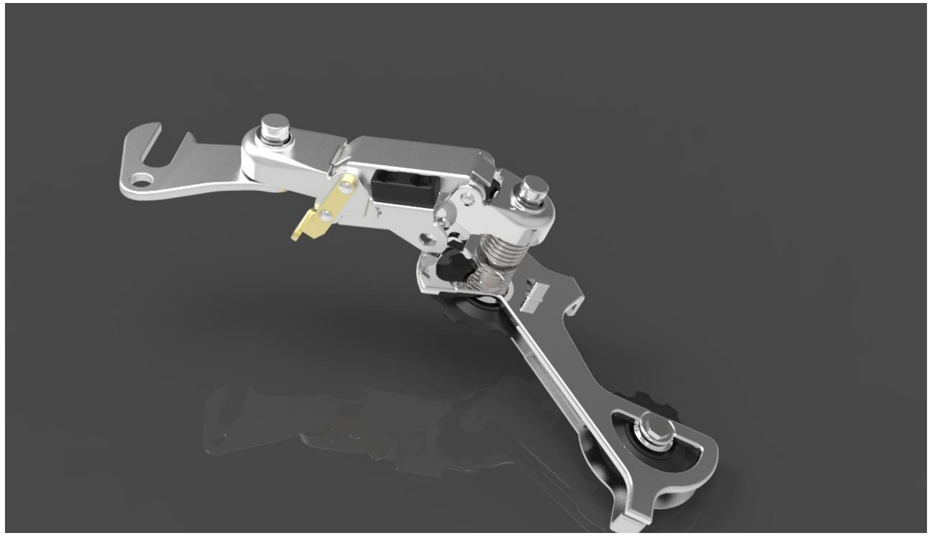
Chain Tube

- L: 304.8 mm, I.D: 12.7 mm, O.D: 15.875 mm
- Avoid Chain grease on clothes
- Guides the chain to the front Crank set.



Derailleur

- Maximize Speed and efficiency
- Allows usage of gears on rear cassette
- Easy to install
- Affordable



Pedaling Speed

$$Speed = Gr * RPM * D * \pi * \frac{miles}{in} * \frac{min}{hr}$$

$$Gr = gear\ ratio$$

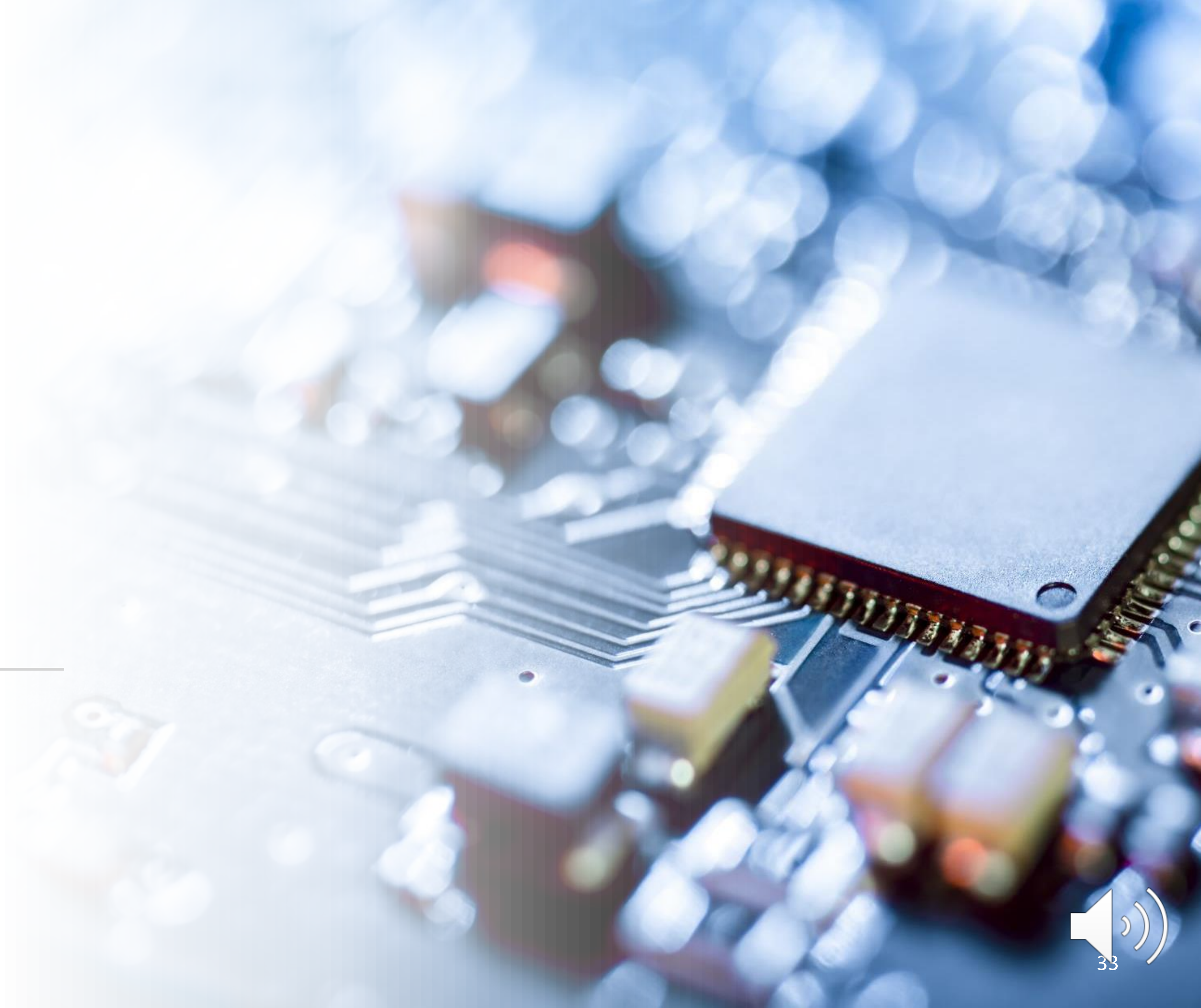
$$RPM = rotations\ per\ minute$$

$$D = diameter\ of\ the\ wheel$$

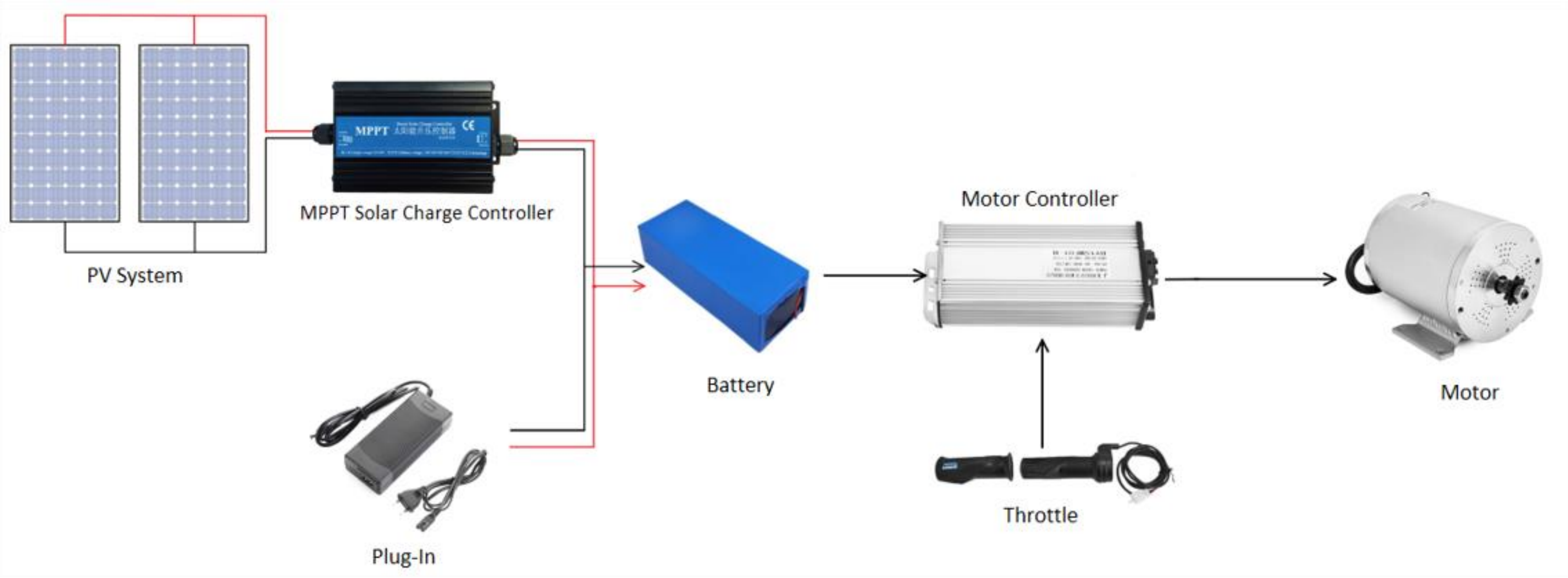
- Efficient crankset rpm = 70
- Speed varies on cog teeth
- Intermediate chainring is 1:1 ratio with crankset
- Speed range from 25.1 to 8.1mph

Cog Teeth	Chainring Teeth	RPM	Speed (mph)
11	48	70	25.1
13			21.2
15			18.4
17			16.2
20			13.8
23			12.0
26			10.7
30			9.2
34			8.1

Power System Process



ELECTRICAL ARCHITECTURE OVERVIEW



MOTOR

48V 1800W Brushless Motor

Sprocket: T8F 9T

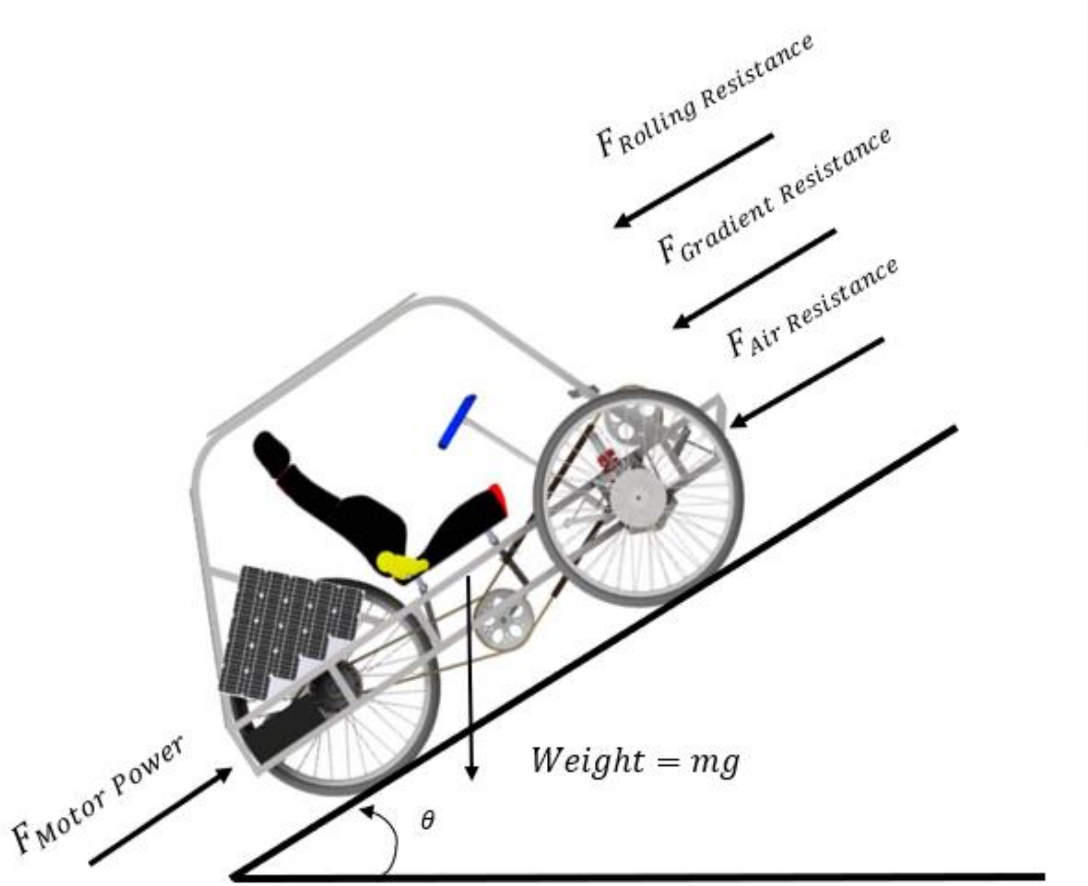
Efficiency: 80%

Motor Weight: 11.7 lbs

Current: 28A

Horsepower: 1.6 HP

Motor Calculations



$$F_{total} = F_{rolling\ Resistance} + F_{Gradient\ Resistance} + F_{air\ resistance}$$

$$F_{rolling\ Resistance} = C_r * m * a$$

- $C_r = Coefficient\ of\ Rolling\ Resistance$
- $m = Mass\ of\ Vehicle\,(kg)$
- $a = Acceleration\ due\ to\ gravity\left(\frac{m}{s^2}\right)$

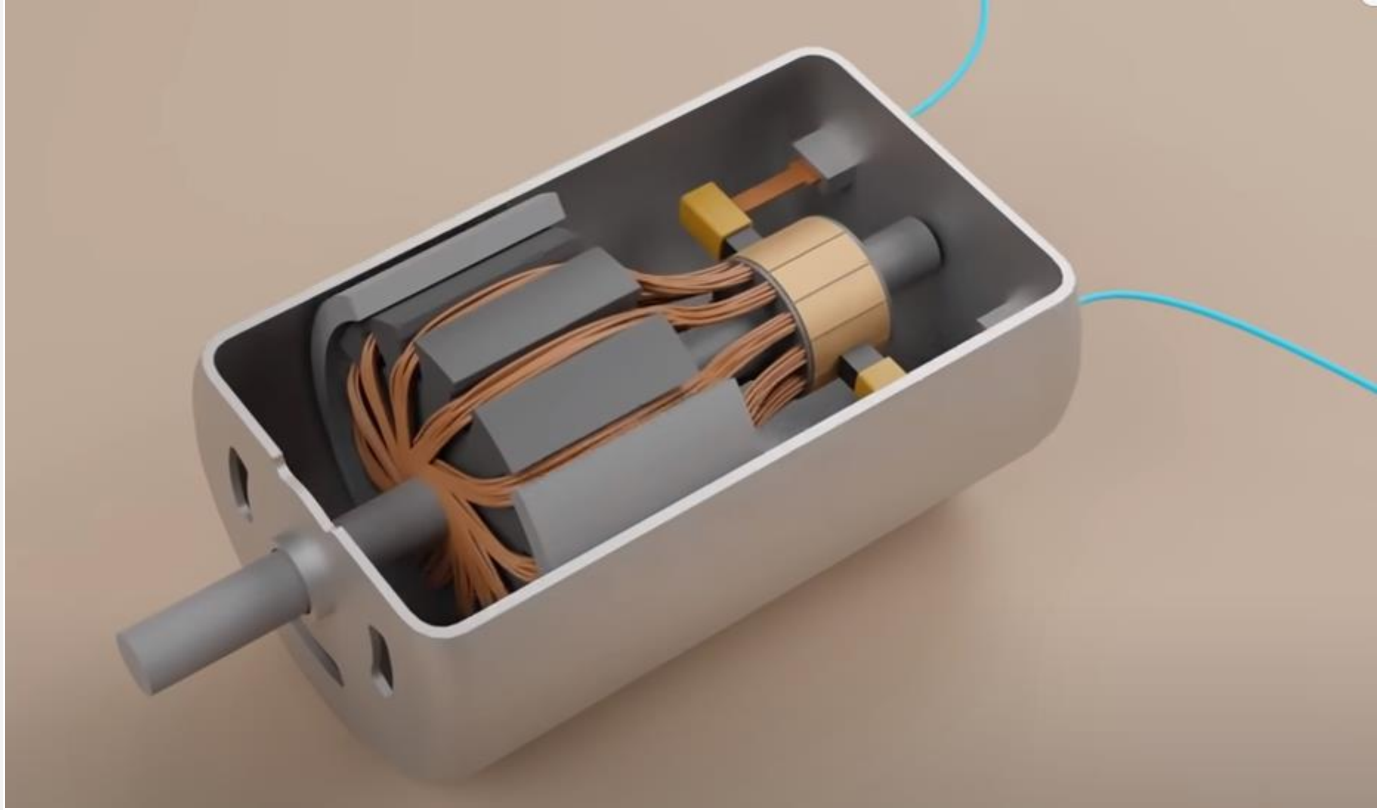
$$F_{gradient} = m * a * sin\theta$$

- $m = Mass\ of\ Vehicle\,(kg)$
- $a = Acceleration\ due\ to\ gravity\left(\frac{m}{s^2}\right)$

$$F_{air\ resistance} = 0.5(\rho * V^2 * C_a * A_f)$$

- $\rho = Density\ of\ Air\left(\frac{kg}{m^3}\right)$
- $V = Velocity\ of\ vehicle\left(\frac{m}{s}\right)$
- $C_A = Coeficcient\ of\ air\ resistance$
- $A_f = Front\ area\ of\ vehicle\,(m^2)$

Advantages/disadvantages



- Direct current (DC) electrical current which only flows in one direction.
- Easy speed regulation and can also be used for immediate start and reverse motions.
- Fed power directly from the power source and requires little to no maintenance.
- Disadvantage is it requires a more complicated speed controller than a brushed motor and has higher initial cost.

BATTERY

- Two lithium-ion batteries are being used
- Batteries specs include:
    - 48 Volts
    - 2000 Watts
    - 20 Amp hours.
- Different adapters being viewed regarding its charging system (i.e., Hybrid Charge)
    - prominent choice - Anderson outlet connection
- As for battery life, this will depend on how much current is used by motor.
- Charging time depends on standard/fast current

Battery Selection Process

Perform for a much longer lifespan

They can withstand extreme low temperatures without failing

Ideal for outdoor applications

Lithium batteries are lighter than alkaline batteries

They offer an advantage when used with portable devices

Battery Specifications

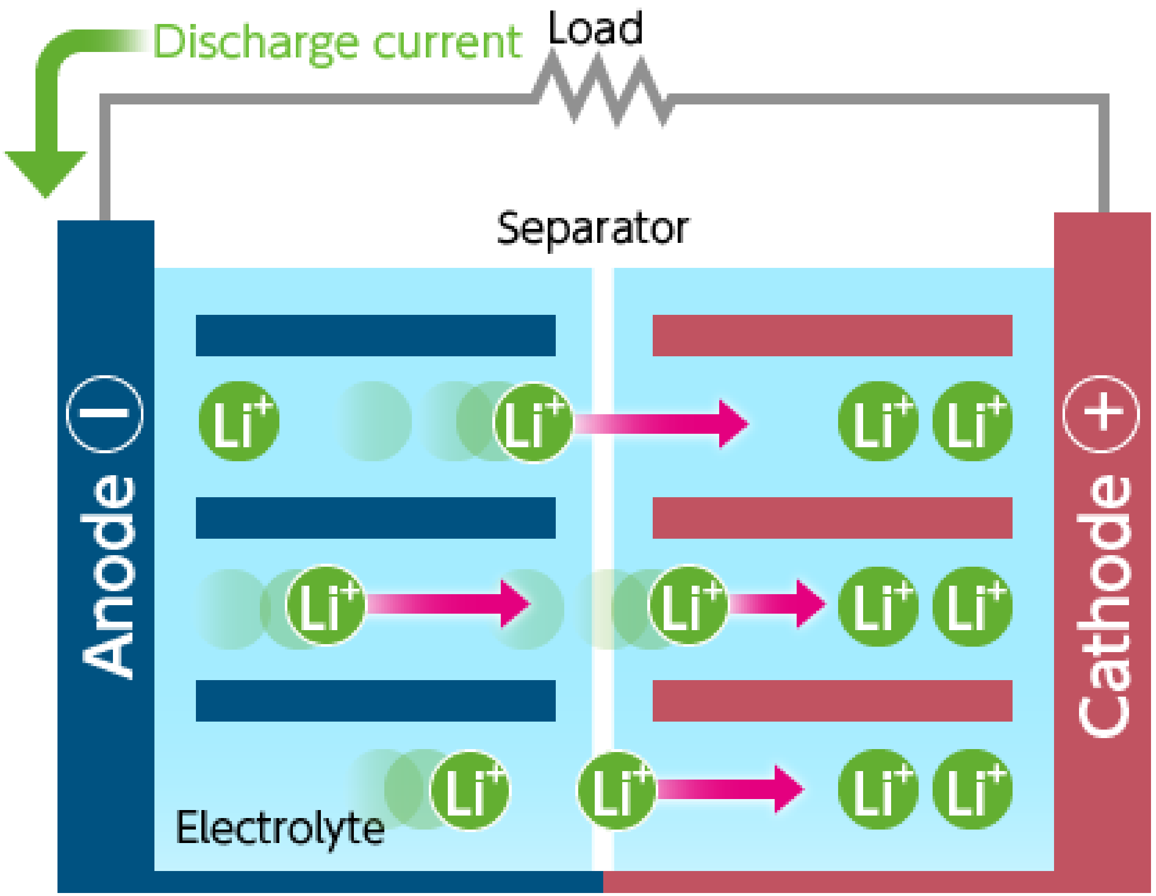
Nominal Voltage (V)	48v
Nominal Capacity (AH)	20ah
Source Resistance (mΩ)	about 20
Cell Specification	20ah 3.7V
Cell Combination	20ah 5x13s
Cell Size	18650
Cell Quantity (parallel*series)	20ah 65pcs
Discharge Cutoff Voltage (V)	38+/- 1V
Charge Cutoff Voltage (V)	54.6v
Rated Discharge Current (A)	30A
instantaneous Maximum Discharge Current (A)	90A
Maximum Continuous Discharge Current (A)	30A
Maximum Continuous Charge Current (A)	5A
Charge Mode	CC-CV
Standard Charge Current (A)	2A
Charge Time under Standard Charge Current	9hours
Fast Charge Current (A)	5A
Charge Time under Fast Charge Current	10hours
Charge Temperature Range	-20-55°C
Cell Size (L*W*T)	250*105*70mm
Battery Weight	About ,20ah 3kg.
Battery Power	1000W

How does it work

Stores chemical energy and converts it to electrical energy

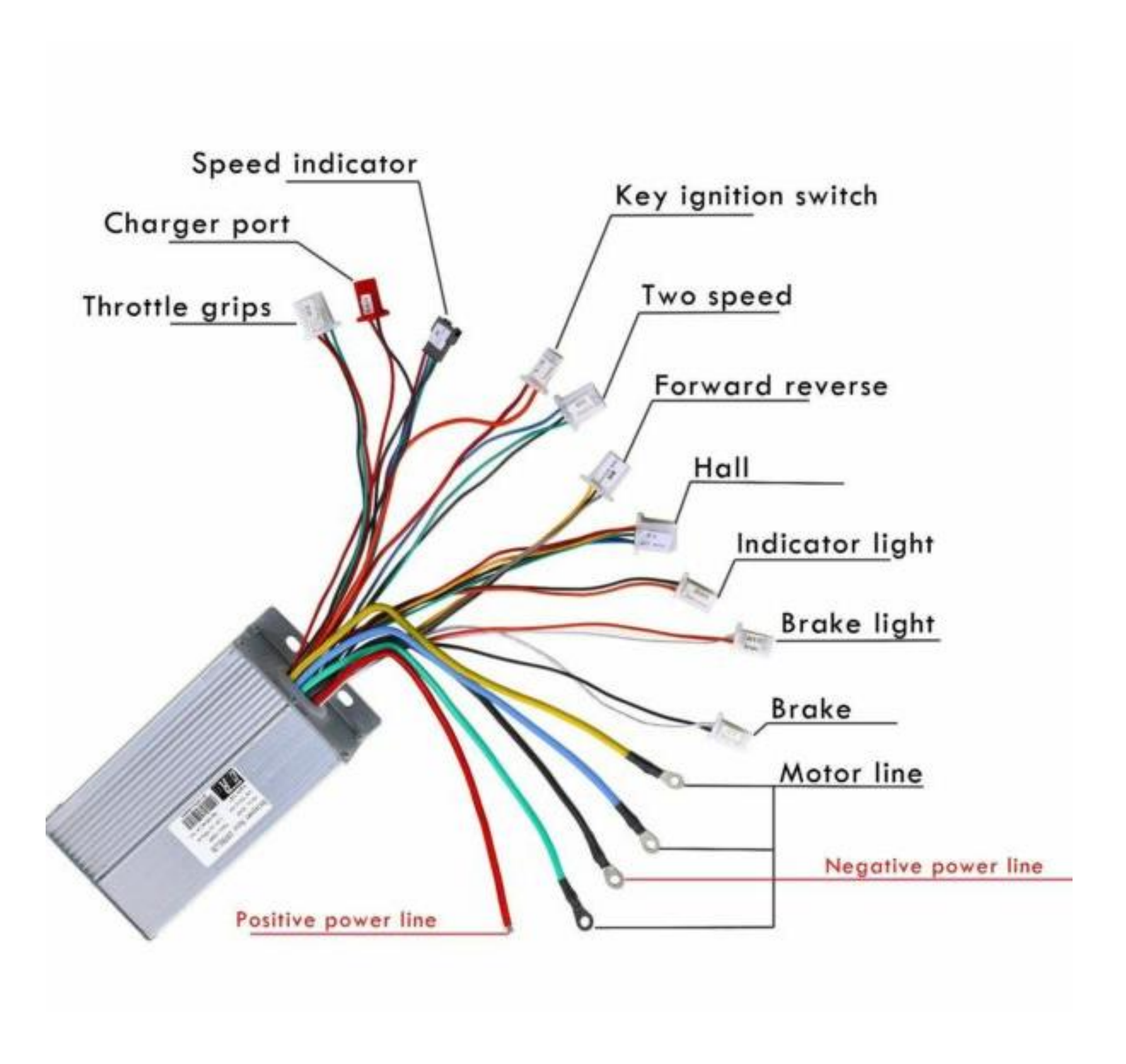
The chemical reactions in a battery involve the flow of electrons from one material (electrode) to another, through an external circuit

The flow of electrons provides an electric current that can be used to do work



Throttle

- Twist grip throttle
- Similar like how a motorcycle or scooter operates
- Provides power to move HMD
- Allows non-use of physical energy



CONTROL SYSTEM

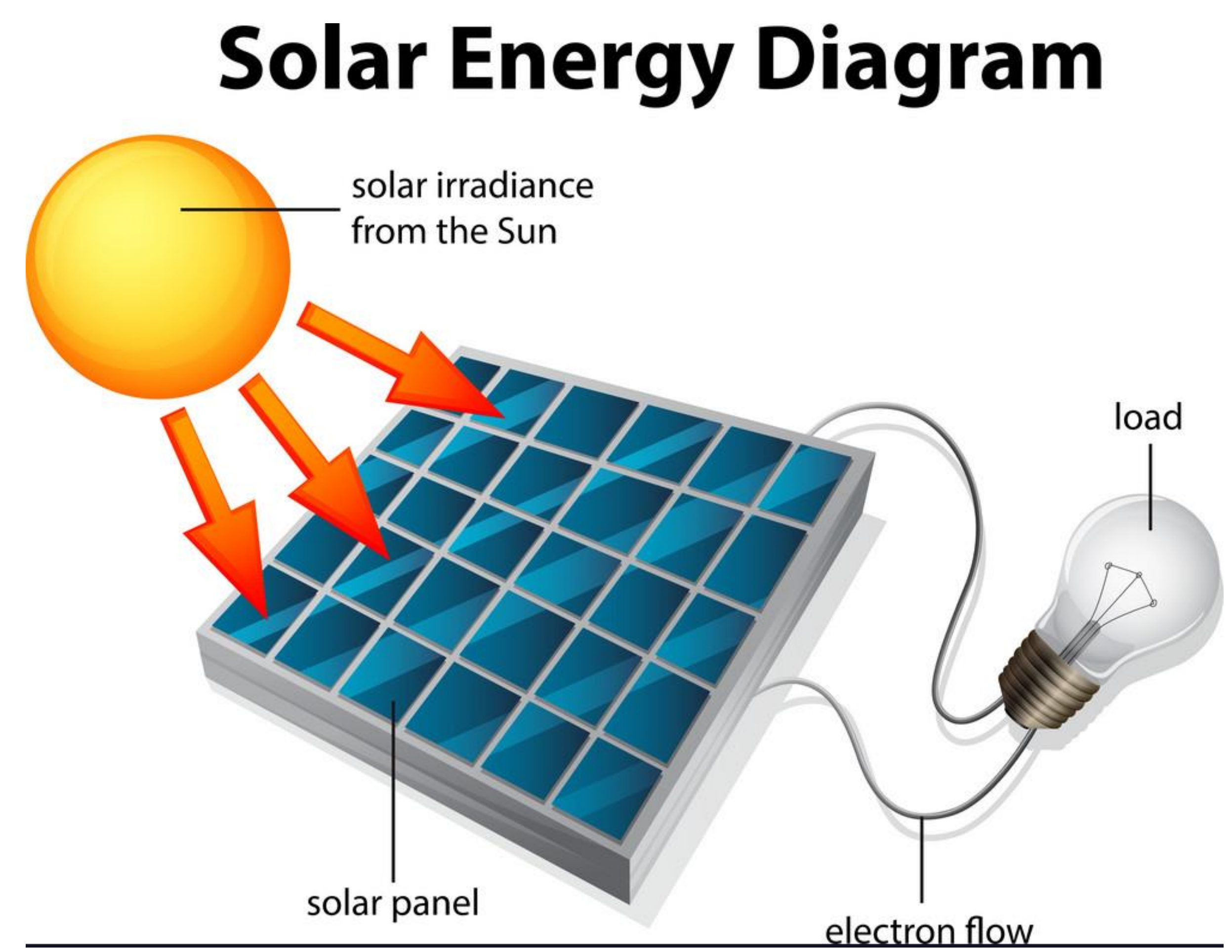
- Motor
- Throttle
- Wiring
- Safety Features
- **Motor Controller Specifications:**
- Rated at: 48V DC/ 32A / 1800W
- Efficiency : 95%

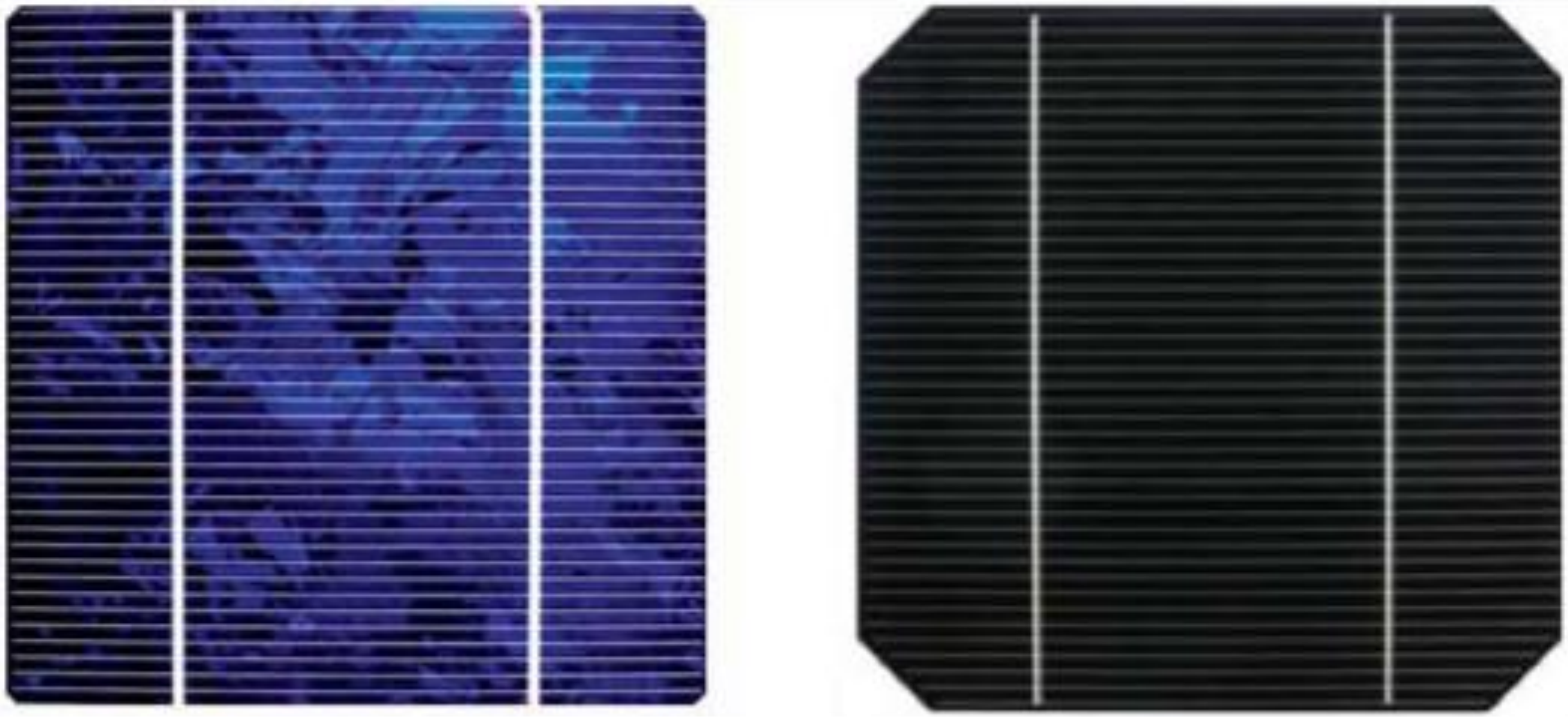
Charging

- Dual Charging
- MPPT Solar Charge Controller
- Current Losses
- Step Up Voltage/Voltage Matching
- Current protection

How do solar panels work?

- Photons knock electrons free from atoms to generate a flow of electricity
- Each cell is sandwiched by two slices of semi-conducting material





Solar Cell

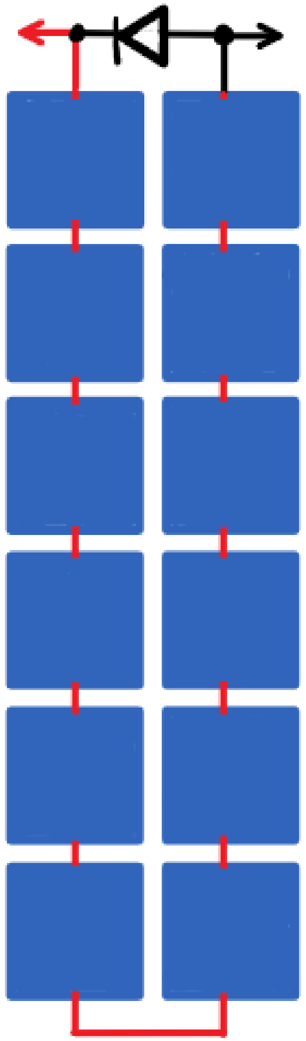
- Polycrystalline vs Monocrystalline
  - Polycrystalline made up of silicon fragments
  - Monocrystalline single-crystal silicon
- Cost-effectiveness
- Deciding factor

Solar Cell Comparison

	MONOCRYSTALLINE	POLYCRYSTALLINE
Size	3 x 3 in	2 x 3 in
Power	1.15 W	0.6 W
Current	2.25 A	1.2 A
Price/Cell	$1	$0.33

Solar Modules

- Series connection
- Every pair will have a bypass diode
  - Total 5 pairs



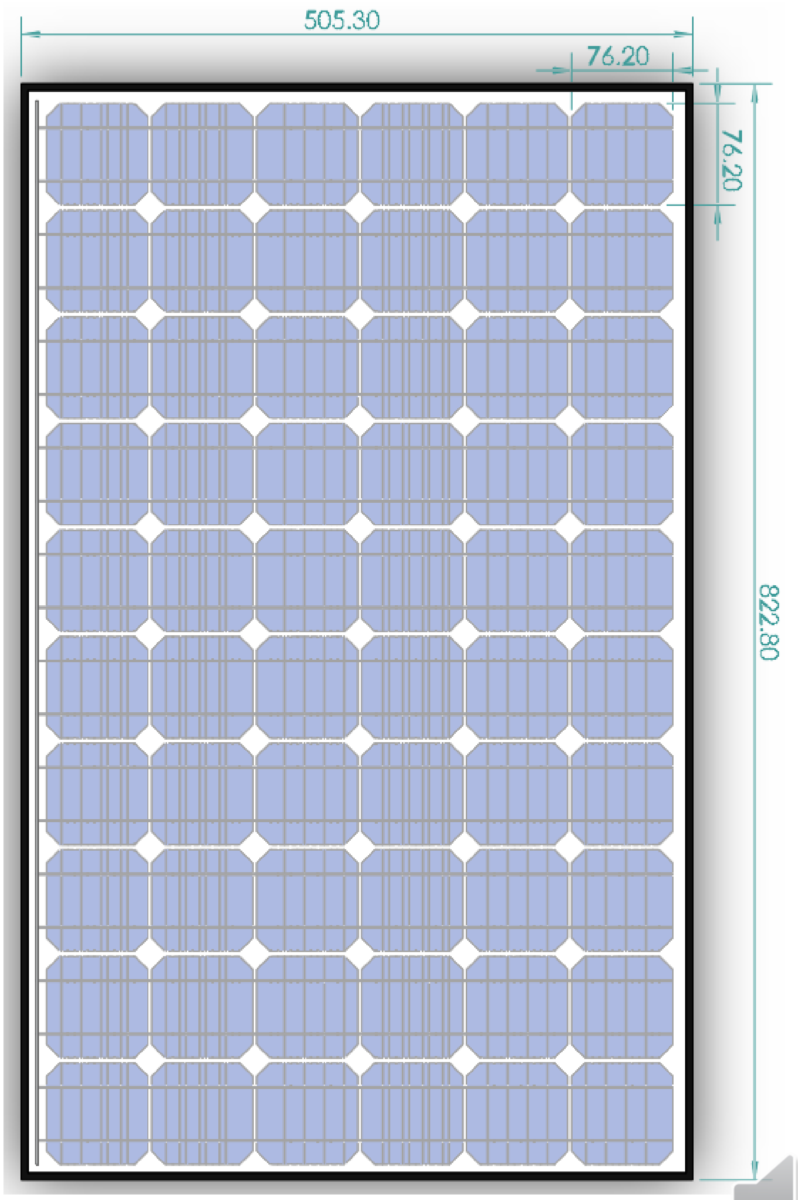
Solar Panel Configuration

- Roll Cage Area:

  Top Portion: 31x19 (in)

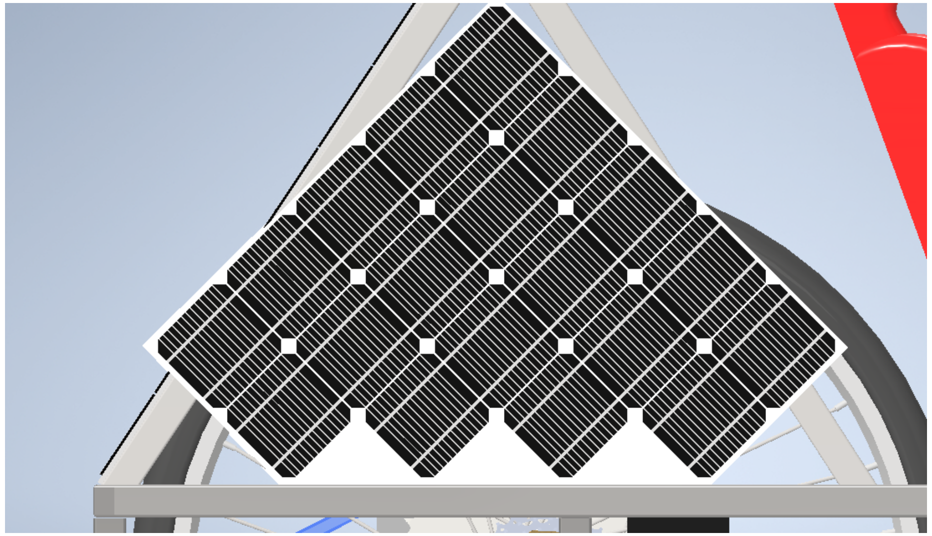
  Rear Portion: 29x19 (in)
- 10x6 Cell Configuration

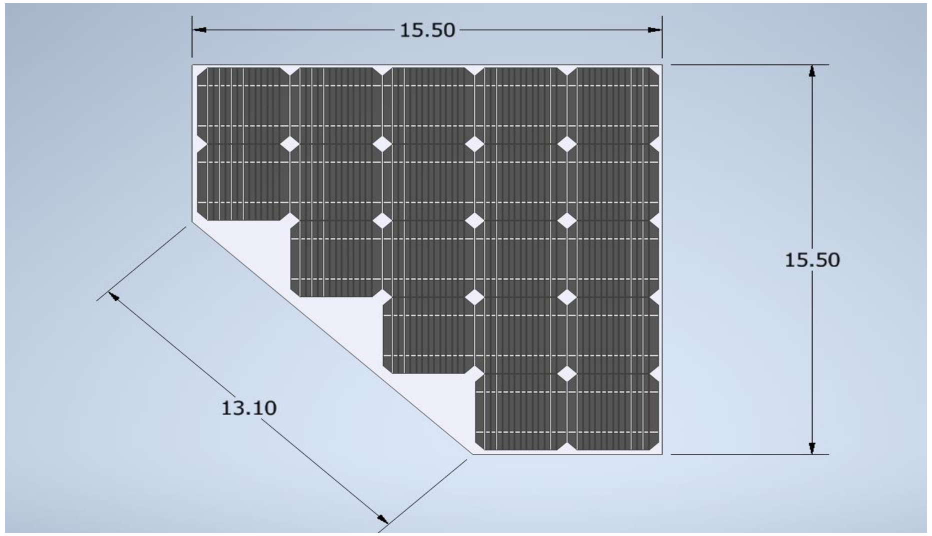
- Panel Rated Output: 30V / 2.4A / 72W
- Total Rated Output: 144W / 30V / 4.8A



Additional Panels

- Triangular panels mounted on the left and right side
- Adds 24 W of power to the system





Solar Panel Construction

Considerations of Solar Panel Construction:

Thermal Aspect

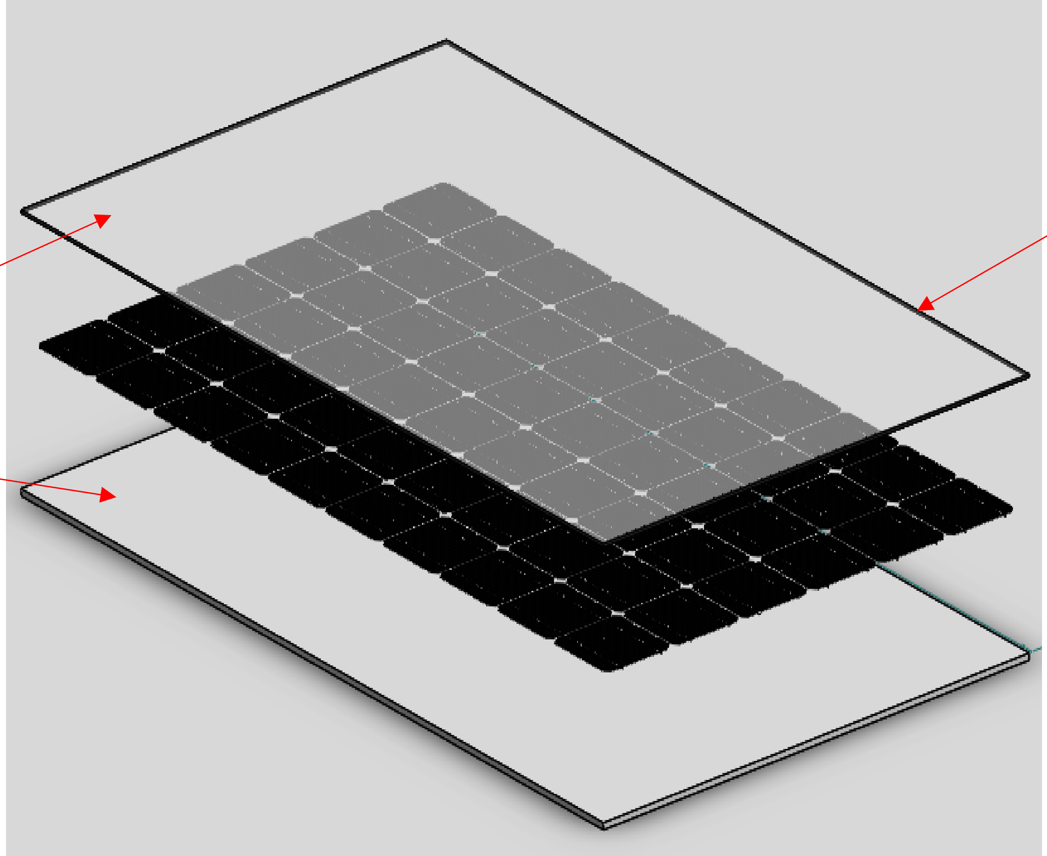
Temperature vs. Efficiency

Bypass Diodes

Prevent Hot Spotting

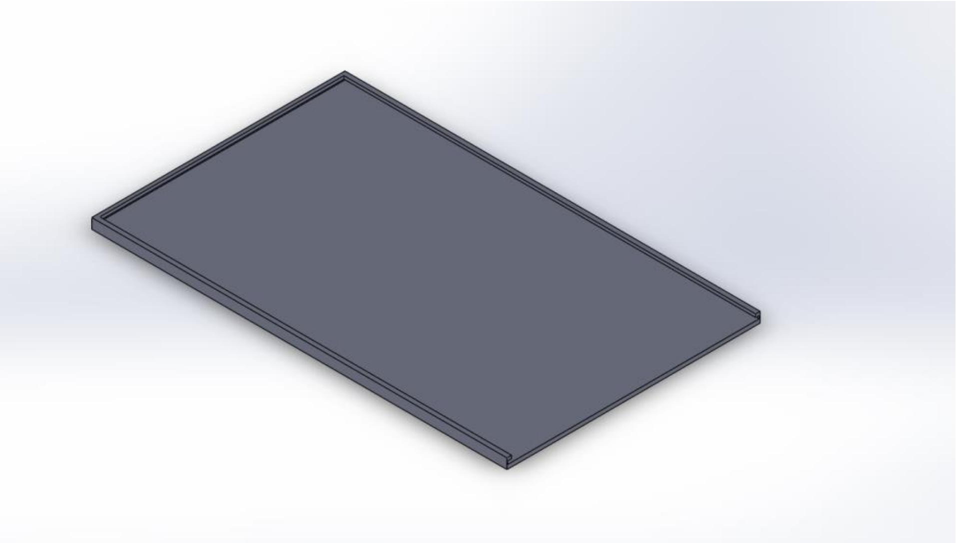
Enclosure

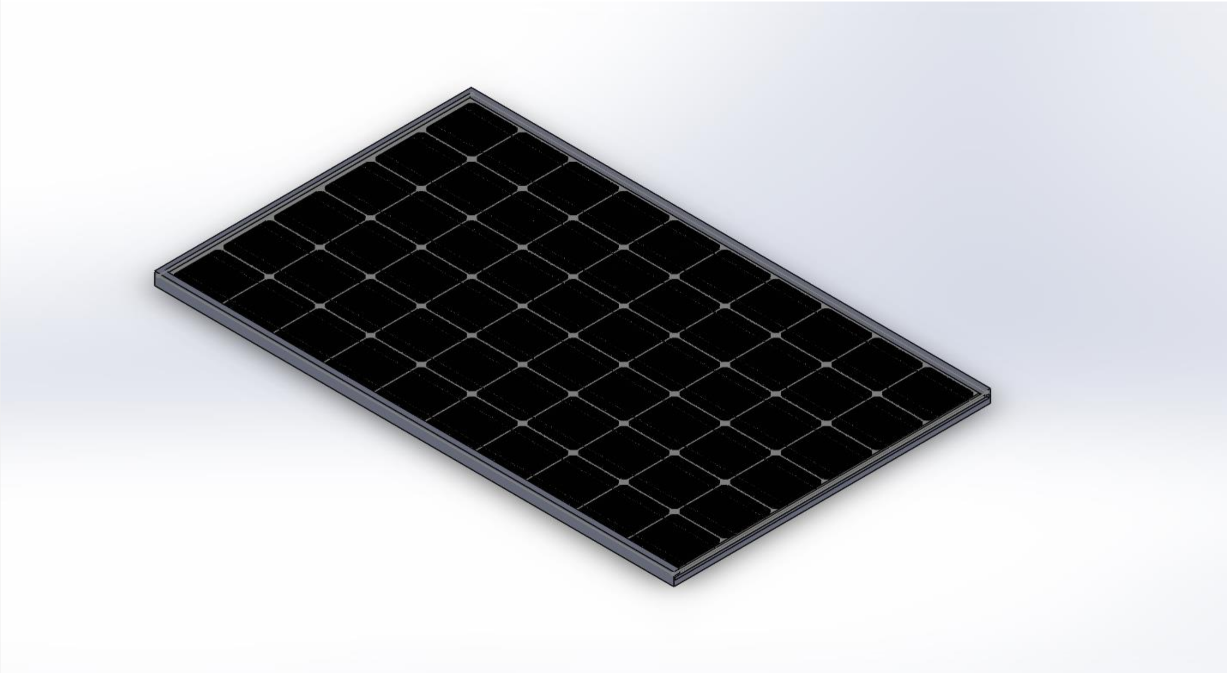
2 – 4 mm acrylic sheets



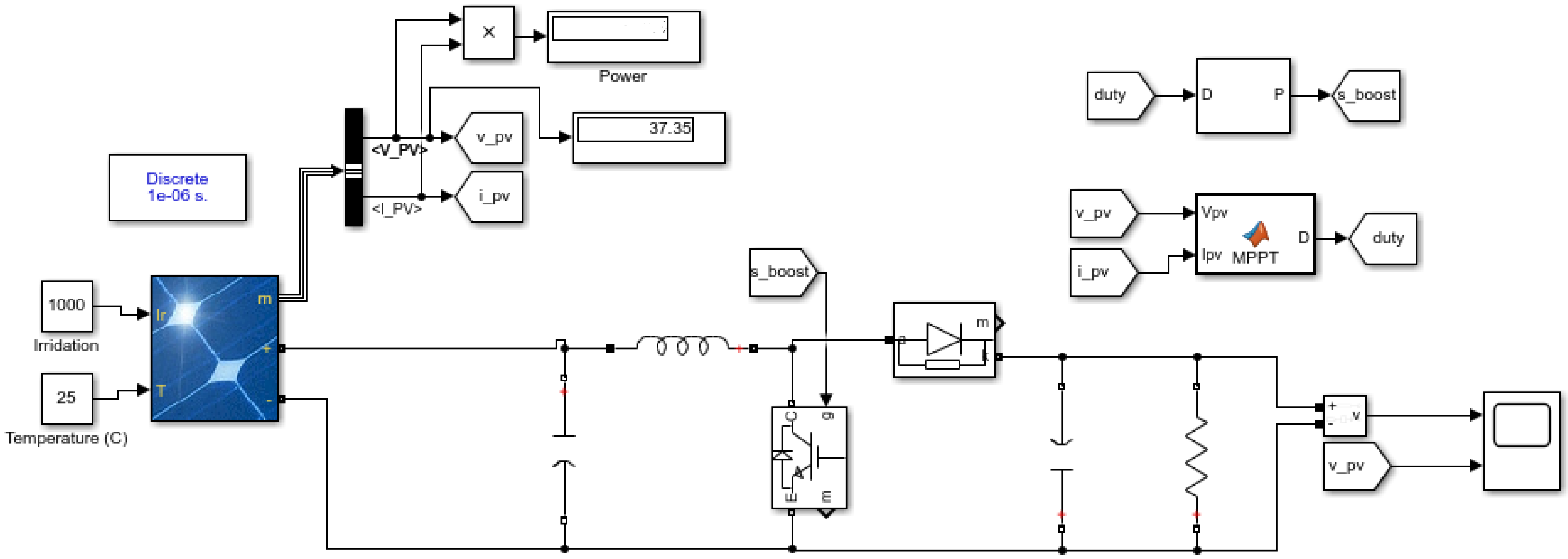
Sealed with weather resistant caulking

Mounting

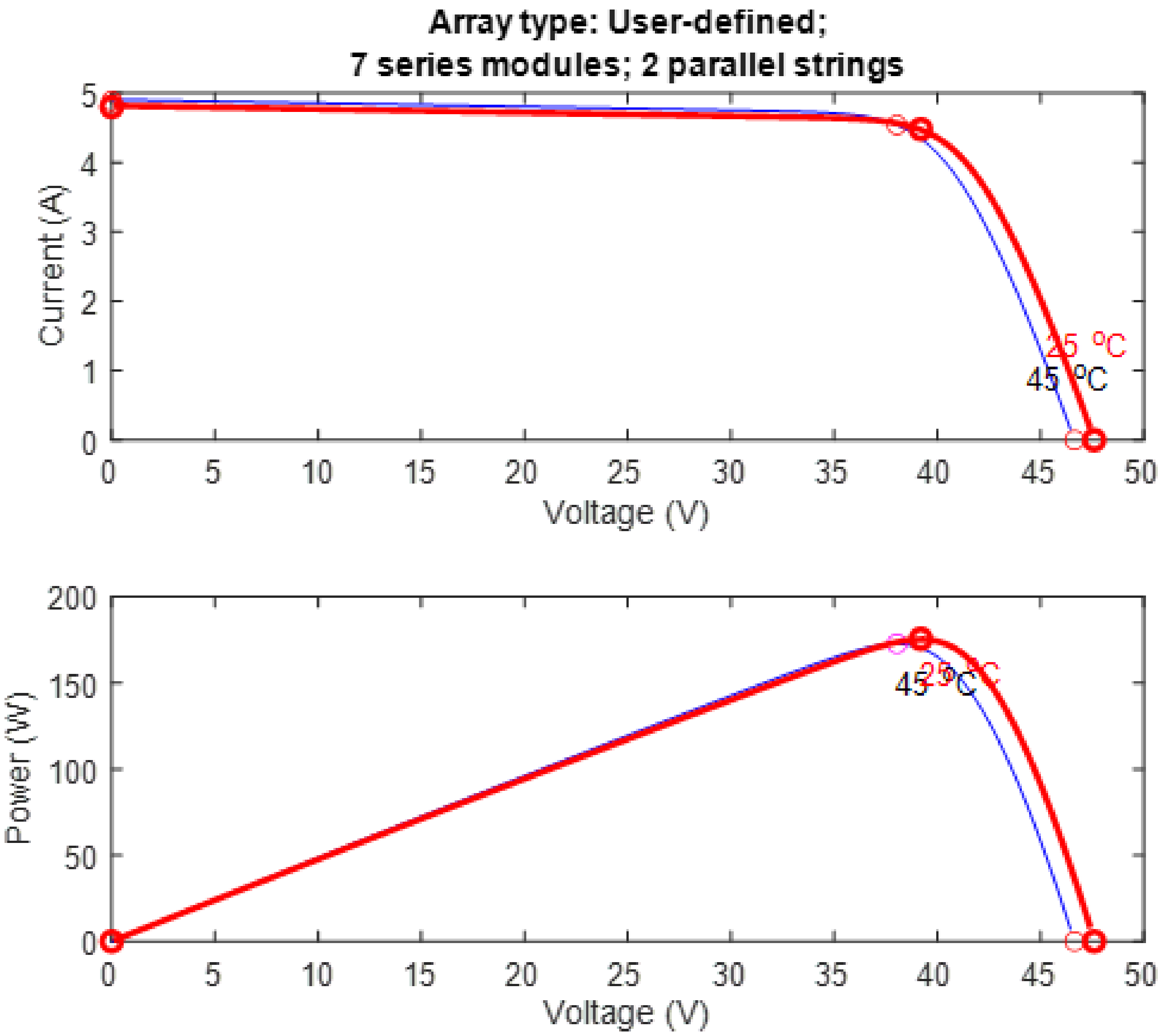




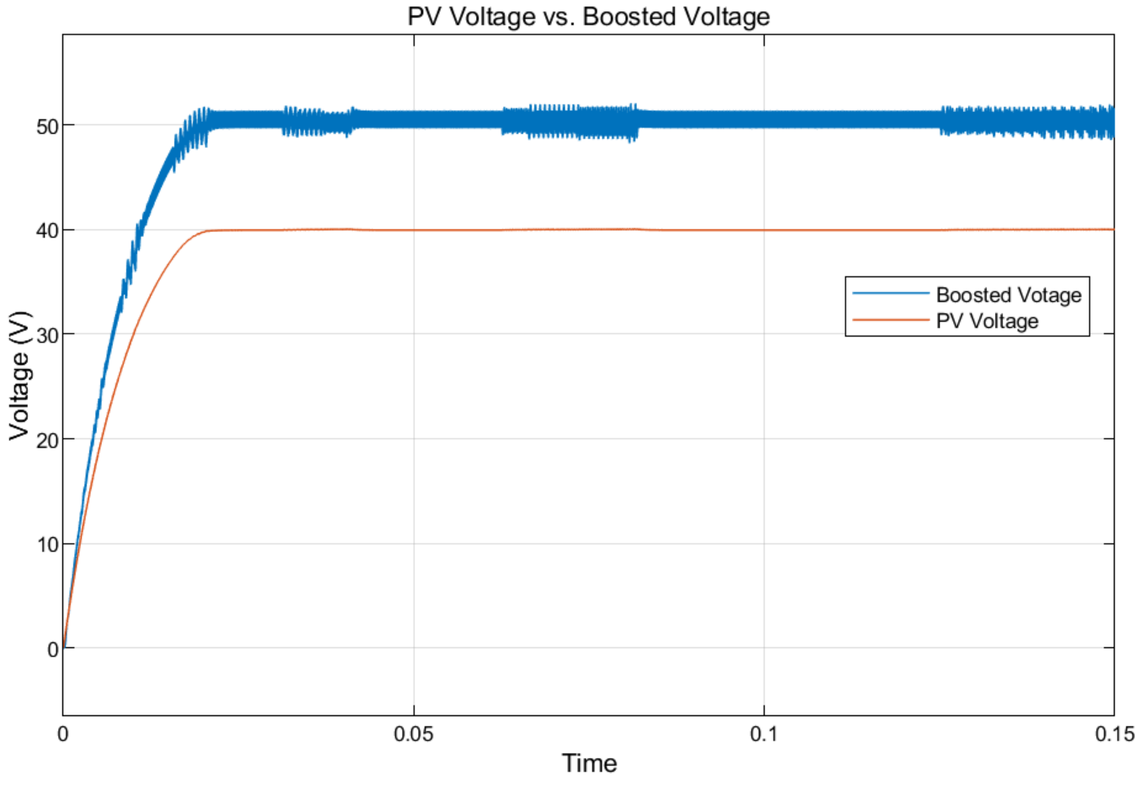
Simulink PV MPPT Model

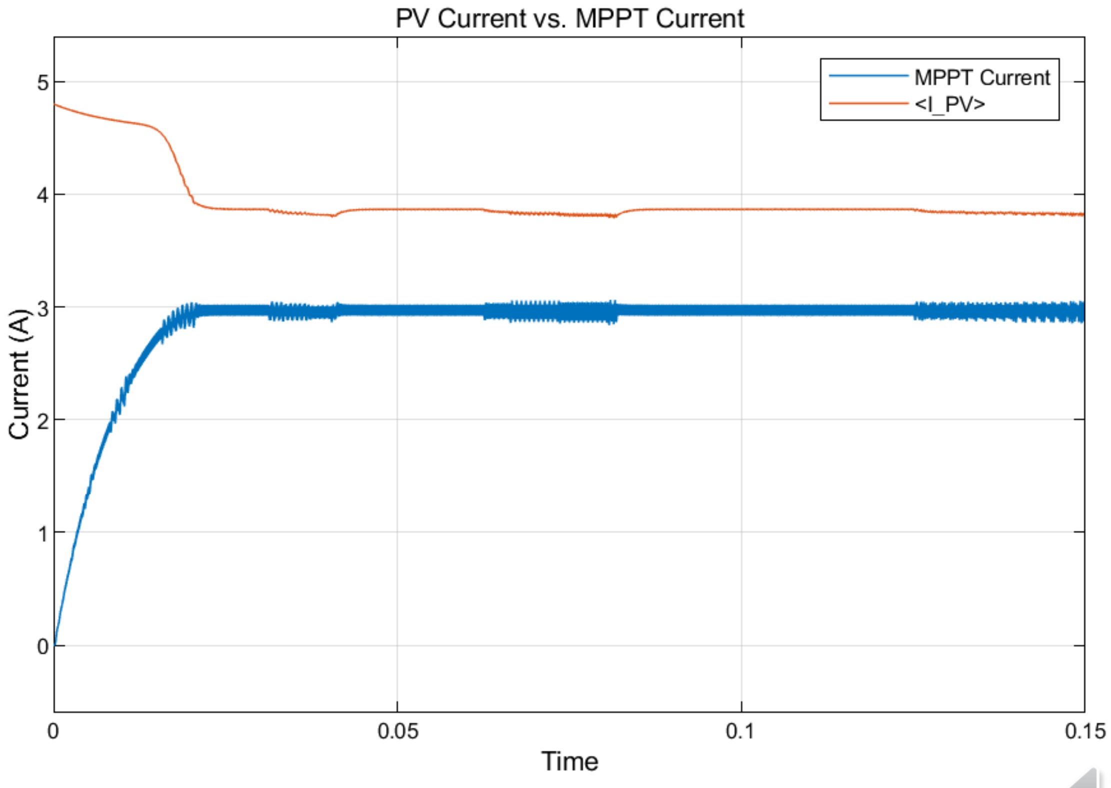


Simulink
PV Array Output



MPPT Current and Voltage





Design Assessment

RISK ANALYSIS - Personnel

Risk	Cause of Risk	Effects of Risk	Risk Mitigation
Health Risks	COVID-19	Pneumonia, respiratory failure, septic shock, flu, and death	Masks, Social Distancing
Safety Hazards	Welding	Burns, eye damage, electrical shock, cuts	Personal Protective Equipment (PPE)
Physical Damage	Manufacturing/ Careless work	Injuries	Following proper protocols and instructions on how to manufacture

RISK ANALYSIS - MECHANICAL

Risk	Cause of Risk	Effects of Risk	Risk Mitigation
Stability & Comfort	Seat mounting	Driver safety	Seat and thick lux foam
Driver safety	Driver being injured or ejected if there is an accident.	Driver safety	Three-point safety harness
Fire	Temperature and cell over-heating	Fire	Fire extinguisher
Driver safety	Debris intrusion into driver compartment	Driver safety	Metal firewall Body panels
Accident or roll over	Accident	Driver safety	Roll cage

RISK ANALYSIS - ELECTRICAL

Risk	Cause of Risk	Effects of Risk	Risk Mitigation
Overheating	Temperature	Fire	Air cool
Hot-spotting	Cells over-heating	Fire/Solar panel failure	Bypass Diodes
Exposed wires	Shift in electrical components	Shock	Cable Ties/Wire Looming
Lithium Battery Leak	Battery Defect	Exposure can cause symptoms such as nausea, vomiting.	Storage, and regular inspection

DESIGN BUDGET

Part	Allowance
Frame	$200
Roll cage	$72
Seat	$200
Drivetrain:	
Steering wheel	$50
Chainrings	2 x $30
Bottom Bracket	$20
2 Chains	2 x $11
Small Rear chain	$5
Derailleur	$30
Wheels	$100
Chain guides	$20
Total:	$287
Mechanical Total:	$800
Battery	$200
Solar Cells	$120
Tabbing wire/connections:	
Tabbing/bus wire	$14.99
Bypass diodes	$6.99
16-gauge wire	$14
TOTAL	$35.98
Charge Controller	$38
Electrical total:	$400
Total budget:	$1200

CONCLUSION

- **Roll cage design**
- **Finite Element Analysis**
- **Drivetrain Design**
- **Seat & Steering Wheel**
- **Solar Cell and Solar panel**
- **Wiring Schematics**
- **Battery**
- **Electrical simulations**